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SOVIET SOIL SCIENCE

12

DECEMBER 1959

A TRANSLATION
OF POCHVOVEDENIYE

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AMERICAN INSTITUTE
OF BIOLOGICAL SCIENCES
2000 P STREET, N.W.
WASHINGTON 6, D. C.

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THE translation and publication o this and other Russian language biologica journals and monographs is a project of th American Institute of Biological Science This project is supported by grants fro the National Science Foundation. Eac publication is a cover-to-cover translatio of its Soviet counterpart and the content are only those of the original authors.

Pochvovedeniye in English translatio bears the Soviet issue numbers. The Sovie journal carries no volume numbers. Tran lation begins with Number 1, the Januar 1958 issue. It is published in the same num ber of issues per year as the original Sovie journals: 12 issues.

translated and produced by
ROYER & ROGER, INC.
INTERNATIONAL DIVISION

Subscription Prices:
$40.00 per year, individuals and industrial librarie
20.00 per year, university and non-profit libraries
3.00 additional to each price for foreign orders
4.50 each, single copies

Order from:

American Institute of Biological Science
2000 P Street, N.W., Washington 6, D.C.

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SOVIET SOIL SCIENCE

translation of the monthly journal—POCHVOVEDENIYE—
publication of the V. V. Dokuchayev Institute of Soil Science,
cademy of Sciences, USSR. A journal founded in 1899.

ochvovedeniye Editorial Board: I. V. Tyurin (editor-in-chief), I. N. Antipov-Karatayev, N. I. orbunov, K. P. Gorshenin. A. A. Zavalishin, V. N. Zavaritskii, S. V. Zonn (assistant editor), . K. Kedrov-Zikhman, V. M. Klechkovskii, V. A. Kovda, M. M. Kononova (assistant editor), Ya. . Peive, I. I. Sinyagin, A. V. Sokolov

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o. 12: December 1959 Translation printed: April 1961

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HE ORGANIZATION OF SOIL RESEARCH N KOLKHOZES AND SOVKHOZES

Our socialist agriculture is confronted with e vastly important problem of increasing the oss annual grain crop to 11 billion poods in e next few years, substantially raising the eld of other crops, and more than doubling e output of animal products.

If this problem is to be solved, we will have increase considerably the yield of all agri- ltural crops and the productivity of forage nds while continuing to expand the areas under ltivation (chiefly with grain) by developing w inefficient productive virgin and abandoned nds.

To increase crop yields is the main and con- ant task of our socialist agriculture and it re- ires resolute and continuous effort. Success- l execution of this task is contingent largely measures designed to improve the fertility d cultural condition of the soil.

Soil is the basis of yield. Together with the imate it is one of the major natural conditions d means of agricultural production. This ealth must be efficiently utilized, progressively nproved, and carefully protected against possi- e destruction or damage by water and wind osion, salinization, water-logging, etc.

Unlike the climate, the soil can be modified to great extent by mechanical treatment, addi- on of fertilizers, meliorative measures, etc., that its effective fertility, i. e., the ability to oduce crops, may be substantially increased.

We know that despite the high potential fer- ity of most USSR soils now under cultivation, e yield of grains and other basic rops has been low average for a long time. The only excep- on is a few technical crops (e. g., cotton, beet gar, tobacco, tea) which have benefited from vanced technology and heavy fertilization.

The acreage in many districts has been eroded water and wind with sharp decrease or even ss of potential fertility.

Yet the research of scientific agricultural in- itutes and the experience of leading farms in different soil and climatic zones leave no room for doubt that efficient utilization of the soil with correct application of technology, fertilizer, and meliorative measures can soon double the average yield of crops both in the chernozem and non-chernozem zones. Elsewhere in the USSR yields can be enhanced by overcoming erosion, salinization, etc. This will require improvements in organizing agricultural production and specializing it in accordance with the natural features of the various agricultural zones and districts. The execution of large-scale measures to increase fertility and to combat erosion and other adverse phenomena using efficient techniques suited to local soil and climatic conditions will also be necessary.

Exploitation of the achievements of soil science by our agriculture is still far from being complete or systematic because there is no specialized permanent organization charged with helping agriculture in the field of soil science.[1] The importance of soil science in raising productivity has not yet been fully appraised. Frequently all that has taken place is the routine use of the same methods all over the country with no regard for the specific natural features, particularly the soil, in each area.

The variety of soils and natural conditions throughout the vast stretches of the Soviet Union make it essential to adapt the techniques to the group and species of soils, climate, relief, and other natural features. The major differences on a broad zonal scale between podzols of the non-chernozem zone, chernozems of the forest-steppe and steppe zones, and light-colored soils (sierozems) of the arid and hot regions are well known. The principal method of increasing the fertility of podzolic soils is to use organic and mineral fertilizers and lime and to sow grasses. In the chernozem zone the accumulation and conservation of moisture in the soil is of primary importance. In the more arid regions of Central Asia and Transcaucasia irrigation combined with large amounts of mineral fertilizer is essential for cotton and alfalfa.

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[1] This fact has attracted the attention of some foreign soil scientists. For example, according to Jacks, Russian soil science is 25 years ahead of the west in its general scientific ideas but 25 years behind in applying these ideas in agriculture (G. V. Jacks.) "The Influence of Man on Soil Fertility." Reprint from The Advancement of Science, September 1956, No. 50.

Besides the aforementioned examples of major zonal differences in agricultural conditions, the differences among soils within the zones of regions, districts, and even kolkhozes and sovkhozes are highly significant. These differences, caused by the diversity of soils, make it necessary owing to local conditions — relief, composition of parent material, length of time the land has been tilled, and degree of improvement — to use different techniques, fertilizers, and meliorative measures compatibly combined and strictly differentiated in accordance with the soil characteristics. These measures will be maximally effective and fertility steadily increased along with greater productivity of labor only if these conditions are met.

We know, for example, that the liming of acid podzolic soils in the non-chernozem zone is effective and essential for increasing fertility. However, before one resorts to liming, the knowledge that the farm is in the podzolic zone is not sufficient. One must also have accurate information on the degree of acidity and soil texture in the different fields in order to determine correctly the lime requirements, the time to add the lime, the amounts, etc.

The same holds true for mineral fertilizers. They cannot be effective unless used in the correct amounts as determined by chemical analysis of the soil and requirements of the crops. Water-logged and peat-bog soils in the same non-chernozem zone cannot be utilized and improved until they are drained. This is possible only after a special investigation is made to determine the group and species of the water-logged or bog soils.

The data from special research on melioration and development of solonetz in the chernozem and chestnut soil zones are equally essential. Development and melioration methods will depend on the group and species of solonetz nature of their occurrence, and degree to which they are present in the cultivated area. We could cite many more examples testifying to the necessity for using the data obtained by soil science to solve such important problems as the correct layout of lands, use of fertilizers, rotation of crops, methods of cultivation, meliorative measures, etc.

Raising the level of agriculture is inconceivable without extensive utilization of soil science. Hence, the agronomists must work in close cooperation with the soil scientists.

This is common practice in several people's democracies, the well established soil conservation and research service of the United States, the national soil and agronomic service of England, and in the corresponding organizations of other western European countries, Australia, New Zealand, etc. Properly compiled soil maps of the districts and individual kolkhozes and sovkhozes should be the basis for correct selection of measures to increase soil fertility. These maps should contain a detailed description of the soils and specific instructions on how to improve them, including techniques of cultivation, use of fertilizers, and reclamation. Compilation, periodic correction and improvement of the maps should be the responsibility of soil scientists in regional (and republic) institutes, soil sections in regional agricultural administrations (or experimental stations) in collaboration with the agronomists of the district, kolkhozes, and sovkhozes, and the soil scientists and chemists of regional and republic laboratories.

Kolkhoz and sovkhoz soil maps have been compiled by soil scientists of land organization administrations sometimes working without any scientific guidance or control and away from agronomists. The quality of these maps and explanatory notes is not always satisfactory. The result is that they are improperly used in the kolkhozes and provide little help in determining individual methods, correct use of fertilizers, efficient organization of the land, etc. These deficiencies must be overcome. The maps and notes must be improved by including agronomic recommendations comprehensive to kolkhoz and sovkhoz agronomists and managers. The combined efforts of the soil scientists, chemists, and agronomists to compile soil maps should be routinely continued by the preparation of a long-range plan for organizing the territory and over-all system of technical and meliorative measures to increase soil fertility and for checking on their implementation. Much has been done here in connection with the soil investigations conducted in the Ukrainian SSR and Byelorussian SSR. Unfortunately, however, in most instances the number of chemical analyses has not been enough to permit a correct solution of the practical problems involved in the use of fertilizers.

The compilation of soil maps of kolkhozes and sovkhozes (together with the necessary appendices) is very important, but it is only the first step in the efforts of soil scientists and chemists to create the necessary conditions for raising agricultural productivity. The task of effecting periodic mass control of changes in the soil and its fertility is now becoming increasingly evident.

The urgency and significance of work in this ld has become apparent due to the growing ale on which powerful modern means of mecical cultivation, intensive application of ferzers and meliorative measures are being ed. The study and control of changes in the operties of soil should be the basis for prompt dification of cultural practices and application fertilizers and for eliminating unfavorable tors like soil erosion and exhaustion, salinity, ter-logging, etc. A major part in this work be played by local chemistry laboratories in tricts and in large kolkhozes and sovkhozes, ich should help the regional soil chemistry oratories.

Besides the application of soil science directto the operations of kolkhozes and sovkhozes, s now essential to utilize the fruits of rerch for state and regional planning and guide. The main task of soil science here is to ovide a qualitative registration of the land sources of the country. This registration st be closely coordinated with the system of te registration of lands and checks on the ndition and utilization of the country's territial resources. In addition, it must serve a secure foundation for forward planning l implementation of measures designed to serve and increase the fertility of USSR ls.

Since a qualitative registration of soils on all-union scale has not yet been made, the tribution of soil science to the many probns of agricultural planning has been hapzard and unsystematic. Meanwhile, the akness or lack of suitable materials on nature of the soils in various areas somees does great harm to the national economy. te, for example, the abandonment of much merly valuable, well irrigated lands bease of salinization; the damage of lands by condary water-logging in the northern and tral districts; and the great harm done by l erosion on slopes, the blowing away of properly used coarse soils and formation sand dunes.

It is clear that we must greatly improve our thods for using soil science and chemistry agriculture. We must create for this purpose pecial organization combining general operanal and scientific methods guidance -- a Soil l Agricultural Chemistry Service.

One of the main functions of this organization l be to conduct soil research in the kolkhozes l sovkhozes in connection with the preparation soil and agronomic maps containing explanay text and cartograms for differential appliion of fertilizers, liming, erosion control asures, salinization, etc.

Another and equally important task will be to p current on the condition and changes in l fertility resulting from the technical, fertilization, and improvement measures employed.

The Soil and Agricultural Chemistry Service will also be responsible for organizing, collecting, storing, and classifying all soil, particularly cartographic, materials as well as coordinating and registering all the soil cartographic work performed by USSR organizations and institutes.

It will be essential to discover the areas whose soils are threatened with destruction by water erosion and flowing or decreased fertility from salinization, water-logging, sand drifts, etc., and to cooperate in designing measures to combat these phenomena and execute state control over the implementation and effectiveness of the conservation measures.

In order to raise the level of agriculture, this organization jointly with the All-Union Society of Soil Scientists and its branches and divisions will have to conduct an extensive educational campaign on the properties of soils and methods of progressively increasing fertility.

The main operational agencies of the Soil and Agricultural Chemistry should be the research and production sections of the regional and subdistrict and agricultural administrations or the ministries of agriculture in the autonomous republics. They should include:

1) A group of soil scientists to compile soil maps of kolkhozes and sovkhozes and to carry out long-range projects and inspection duties (e. g., on erosion);

2) A soil chemistry laboratory for mass analyses;

3) A cartographic bureau and, as needed, such specialists as geobotanists, agronomists, and reclamation engineers.

The regional soil sections will naturally maintain close liaison with local research and experimental organizations and make extensive use of their data to raise soil productivity.

Regional soil sections and laboratories must provide advice on organization and methods to district laboratories and to the laboratories of sovkhozes and kolkhozes charged with making current soil analyses for correct fertilizer application and checking on soil fertility. A regional laboratory, therefore, should have a soil scientist as director, a chemist, and technicians along with suitable equipment.

Small advisory groups attached to the ministries of agriculture in the union republics and the main operational center in the USSR Ministry of Agriculture should be set up to give general guidance to regional (subdistrict) sections.

A permanent Bureau of Scientific Methods should be constituted in the All-Union Fertilizer and Soil Science Institute (VIUA) with members appointed by the scientific institutions working on soil science and agricultural chemistry of the V. I. Lenin All-Union Academy of Agricultural Sciences (VASKhNIL) and Academy of Sciences USSR and by the main planning and exploring groups engaged in soil research.

The Bureau will be responsible for working out instructions on methods and technical conditions for conducting all types of soil, chemical, and reclamation research and checking on the work of the local organizations of the Soil and Agricultural Chemistry Service. All the soil research agencies of the USSR and Society of Soil Scientists, including personnel stationed at headquarters and in the field, will cooperate in its organization and work.

If set up in accordance with the criteria mentioned previously, the Soil and Agricultural Chemistry Service will be an active and vital agency affording help in making efficient use of the land and in conserving and increasing fertility — the foundation of the prosperity of our great nation.

In addition, there will have to be measures to improve the training of soil scientists and agricultural chemists in the universities and agricultural schools. This is completely feasible.

As for the inevitable costs, they will be jus fied by the better use of the soil and increased productivity resulting from the creation of an efficient "service of soil science, fertilizers, and soil conservation."

The idea of having such a service has been frequently discussed in recent years. More than five years ago it was again proposed by th V. V. Dokuchayev Soil Institute of the Academy of Sciences USSR. The plan was approved by t Scientific and Technical Council of the Ministr of Agriculture and unanimously endorsed by the All-Union Conferences of Soil Scientists in 1954 and 1956.

Several union republics have already organized a "soil science service" and it has full justified itself.

Let us hope that during the next seven years the Soil and Agricultural Chemistry Service will be set up on a national scale and that it will help to raise the level of our agriculture, enhance the fertility of USSR soils, and increase crop yields.

Soil and chemistry sections should be established in zonal institutes and regional exper mental stations to work out scientific solutions for the problems involved in increasing soil fertility locally.

ROBLEMS OF SOIL SCIENTISTS OF THE CENTRAL CHERNOZEM BLASTS IN CONNECTION WITH THE SEVEN—YEAR PLAN OR DEVELOPMENT OF USSR NATIONAL ECONOMY

G. ADERIKHIN,

The Twenty-First Congress of the Communist
rty of the Soviet Union set before agriculture
l agronomy major problems. These problems
defined in the control figures for develop-
nt of the national economy in 1959-1965, pro-
ing for an over-all increase in gross agri-
tural production by 1.7 times. In the current
en-year plan it is necessary to achieve a
siderable improvement in land utilization as
basic resource of agricultural production.

The control figures for development of the
ional economy of the USSR in 1959-1965 state
t "the main direction in development of agri-
ture in the forthcoming period remains the in-
ase in production of grain as the foundation of
agricultural production," wherein the kolkhozes
sovkhozes of the Central Chernozem Oblasts'
O) will henceforth be among the basic pro-
ers of commercial grain. In addition to this,
vision is made for expanded plantings of sugar
t, sunflower, potatoes and other crops as well
a considerable increase in their productivity.
nsistent high yields of all agricultural crops
attainment of the stipulated gross product
st be achieved on the basis of introduction of
cientifically based system of agriculture suit-
e for the conditions of the individual economic
ions of the country, the utmost specialization
improvement of allocation of agricultural pro-
tion, and the wide use of scientific achieve-
nts and advanced experience. The practical
oduction of the proper system for conduct of
iculture must be treated as a matter of great
rest to the state.[1]

Soil science agricultural chemistry has an
ortant role to play in the successful solu-
of the problems placed before agriculture
the Twenty-First Party Congress. As is
wn, soil science arose from the necessity
gricultural practice, and throughout its
stence has been devoted to the development
gricultural science and production. This is attested to in the works of V. V. Dokuchayev, P. A. Kostychev, V. P. Vil'yams, K. K. Gedroyts, D. N. Pryanishnikov, L. I. Prasolov, et al.

In the light of the decisions of the Twenty-First Party Congress great tasks confront Soviet soil science and, consequently, also the soil scientists of the CCO. The various soil-climatic conditions of the Soviet Union and the CCO require a differentiated approach to utilization of soils and development of complex measures for altering soil properties in order to insure maximum productivity. In this connection soil scientists must accelerate the conduct of a detailed study of soils and their cartography, explaining expeditions, station and laboratory investigations in various regions.

The central chernozem oblasts are the wealthiest soil regions. Their chernozems have a reputation for high productivity. However, owing to exploitation of chernozems before the Great October Socialist Revolution they were overworked in some areas and became subject to intensive erosion, with the result that there was a sharp reduction in their productivity and agricultural yields. The problem now confronting us is to expand the thorough study of the soils of the CCO. The soils of the CCO have been studied by V. V. Dokuchayev, P. A. Kostychev, N. M. Sibirtsev, K. D. Glinka, P. V. Ototskiy, K. G. Freyberg, A. M. Pankov, G. M. Tumin and many others. However, before the Great October Socialist Revolution the soils, of these oblasts' were little studied. The wide investigation of CCO soils for purposes of compiling large-scale soil maps began in 1929 in compliance with the policy of the oblast' administrations of agriculture. Large-scale kolkhoz and sovkhoz maps were compiled for the investigated oblasts' and rayons.

In the current seven-year plan soil scientists are confronted with the task of improving the detailed investigation of soils and the compilation of large-scale soil maps and soil cartograms of kolkhozes with a detailed and multi-

---

Control figures for development of USSR National
nomy 1959-1965.

farious characterization of all soils. As is known, soil maps are of vast importance. They serve above all as the basis for the state's qualitative land appraisal in the country and the oblast', the planning of statewide, oblast' and rayon measures in agriculture; they are the scientific foundation for the practical application of agricultural procedures in kolkhozes and sovkhozes.

Despite the fact that study of the soils of the central chernozem oblasts' began earlier than in other oblasts' of the Soviet Union, the land appraisal is far from concluded. Soil scientists still do not have at their disposal data concerning the qualitative distribution of various soil groups within the limits of the CCO. The same is true of soil textures. There are no materials characterizing distribution of soils according to relief elements, indicating the distribution and nature of eroded and flood-plain soils.

There is considerable cartographic material for individual Central Chernozem Oblasts'. In Kursk and Tambov Oblasts' large-scale cartography of kolkhoz and sovkhoz soils has been completed; the Belgorod, Voronezh and Orlovsk Oblasts' they are almost concluded. Lipetsk Oblast' is somewhat behind in this work, but in recent years has intensified the tempo of work in field investigation and soil mapping. Regrettably, the work of generalization of the accumulated material is proceeding extremely slowly.

In this connection the soil scientists of the CCO are confronted with the task of accelerating work in compiling unfinished maps in oblasts'. It is also necessary to achieve a considerable increase in quality of this work, to accelerate the generalization of cartographic and analytical material and, on the basis of this, to compile in all oblasts' soil maps of a scale of 1:200,000 and in rayons on a scale of 1:50,000 with the development of a production characteristic. Efforts must be increased to propagandize soil science and to explain to the rural population the necessity for using soil maps at kolkhozes and sovkhozes as well as procedures for using them. Kolkhoz and sovkhoz soil maps, which should serve as the basic foundation for differentiated planning and the execution of all measures, in most cases are not properly used, which is a completely senseless state of affairs and must be eliminated.

In studying soil cover it is necessary to devote particular attention to the genesis and classification of soils. Genesis of the principal soil groups of the CCO has commanded the attention of soil scientists. However, for the CCO and adjacent oblasts' the effects of various natural factors on soil formation have not been adequately explained. There is insufficient data on the influence of man's activities on the development of soils. Little attention has been devoted to the question of the direction in which the evolution of soils of the CCO is progressing. Meanwhile, without a study of the genesis and evolution of soils, soi science cannot develop as a theoretical and applied science and cannot be useful for the development of the national economy.

A knowledge of the genesis of soils require that we return to standard investigations of the mineral and organic fractions of soils, soil colloids and the physical-chemical properties of soils, as well as modern soil-producing pro esses, as was emphasized in the report by I. V Tyurin at the First Delegates' Congress of Soi Scientists of the USSR in 1958 and in the decisions of this congress. Some work has been performed in this direction in the CCO (Voronezh University, the Agricultural Institute, the Scientific Research Institute of Agriculture (Central Chernozem Belt) imeni V. V. Dokuch yev, and others) but this work is inadequate and must be developed by all means at educati al institutions and at scientific-research estab lishments.

Along with the study of the genesis of soils it is necessary to develop and perfect their classification. Development of the soil classi fications of the CCO is being undertaken chief by soil scientists of the oblast' administration of agriculture. Until recently this work, performed in individual oblasts' of the CCO, was not coordinated, which led to a variety of inter pretation in classifications. This incongruity was eliminated in 1958 when, at the CCO confe ence of soil scientists in Voronezh, the classi fication of soils of individual oblasts' was stan dardized and unified. As the basis for this standardization the classification developed by the Soil Institute imeni V. V. Dokuchayev AN SSSR was adopted. Further improvement of the soil classifications of the CCO must be achieved in the future, coordinating it with the All-Union classification and the classifications of adjacent oblasts'. It must meet the require ments of science and the demands of productio In improving the CCO soil classification partic ular attention must be paid to intrazonal soils (sandy, solonetz, carbonate, flood-plain, eroded, and others), the classification of whic is as yet undeveloped.

Study of the genesis of soils and developme of their classification serves as the scientific basis for the mapping and cartography of soils in general. With this as the starting point the corresponding divisions of soil science must evolve simultaneously in all oblasts' and republics of the Soviet Union.

Recently in the practice of agriculture in th USSR, including the CCO, the need for a quali tative appraisal of land has arisen. The study of this problem at present is being undertaken

personnel of the V. V. Dokuchayev Soil In-
itute, AN SSSR and other central scientific
search establishments, but the scientific
search establishments and practical workers
the CCO have not been included in this work.
e classification of soils is particularly press-
g at this time. Its successful execution will
ake possible the solution of problems of agri-
ltural-soil regionalization and correct land
e. Hence, the soil scientists and economists
the Central Chernozem Oblasts' must de-
lop this work by all means.

Study of the genesis and geography of soils
well as the problems of agricultural-soil
gionalization and site classification is the
imary task of soil science. Along with this
ere is advanced the task of the thorough study
the chemical, physical-chemical properties
soils, as well as the biological processes
curring in them and the development of scien-
ic bases for increasing their productivity.
t it be pointed out that until recently soil
ientists of the CCO devoted insufficient at-
ntion to the problems of the scientific bases
r increasing soil productivity. The develop-
ent of these problems assumes, above all,
e correct use of soils in agriculture.

These urgent tasks may be solved by soil
ientists and agricultural chemists with the
operation of physiologists, agronomists and
her specialists in agriculture. For develop-
ent of methods of increasing soil productivity
d creating rational systems of agriculture in
e various soil-climatic regions of the CCO it
necessary, in compliance with the decisions
the First Delegates' Congress of Soil Scien-
ts, to evolve thorough standard researches
the following aspects of the nationwide prob-
m as set forth by the V. V. Dokuchayev Soil
stitute, AN SSSR: 1) rotation of materials
agriculture and means of affecting it for the
rpose of increasing crop yields; 2) scien-
ic bases for regulating the nutrients and
oisture conditions of soils; 3) scientific bases
r a radical improvement (melioration) of soils;
scientific bases for controlling soil erosion
d its residual effects.

For a number of years the soil scientists
d agricultural chemists of the faculty of soil
ience of Voronezh University have studied
e phenomena of adsorption of phosphorous,
rogen, sulfur, potassium, calcium, and mag-
sium by soils and plants as well as the dynam-
s of these elements in soils. In 1957, the fac-
y started investigating the chemical properties
soils of the CCO. The faculties of agricultural
emistry and agriculture of the Voronezh Agri-
ltural Institute, the Institute of Agriculture of
e CCB imeni V. V. Dokuchayev, and certain
ricultural experiment stations of the CCO are
work on problems of interaction of soils,
tilizers and plants.

Study of the accumulation and decomposition of organic substances in soils during agricultural use as well as the nutrient cycle of soils is being undertaken by: the faculties of soil science and agricultural chemistry of Voronezh University, the agricultural and soil science faculties of Voronezh SKhI (Agrochemical institute), the Institute of Agriculture of CCB imeni V. V. Dokuchayev, and others. Regrettably, these investigations are being conducted without the necessary coordination and do not have a common guidance. The volume of such work is completely inadequate. Meanwhile the study of available forms of nutrients is extremely important in explaining the seasonal nature and trends of soil formation, processes of mobilization of nutrient substances in dynamics, in establishing the extent to which nutrients of plants are provided during the various vegetative periods, elucidation of the intensity of microbiological processes, as well as for the development of methods of determining plant requirements for fertilizers, improving systems of cultivating, fertilizing and meliorating soils.

Soil scientists are confronted with the problem of providing in the immediate future a complete picture of the biochemical and physical-chemical processes occurring in soils, as the result of which there occurs, on the one hand, an accumulation of organic and mineral substances and, on the other hand, their conversion into available form for plants.

In considering the fact that in most of the CCO the moisture properties of soils are of great importance for agriculture, it is necessary to expand and intensify research in this aspect. In studying moisture regime of soils particular attention must be devoted to determining its laws and to developing scientific bases for regulating it. The latter may be achieved on the condition that investigations are performed on a complex basis.

It is known that the amount of atmospheric precipitation in the CCO (with the exception of drought years) is sufficient to obtain high yields. However, plants are not always adequately provided with soil moisture. This is explained by the peculiarities of the soil moisture regime of these regions. Consequently, it is necessary to evolve such a system of agriculture and cultivation of soils as will ensure complete utilization of atmospheric precipitation by soils and plants. For this purpose it is necessary to study the soil moisture regime under various agricultural crops and to employ a variety of treatments over the course of an entire year so that on this basis, for each type of soil, it will be possible to establish the optimum depth of basic plowing, the time of plowing and the nature of other types of treatment.

Structure of soils is of great importance in regulating their moisture regime. Hence, the study and basic improvement of this regime is necessary and serious attention must be devoted to this problem. At the present time soil structure in the CCO is far from adequately studied. In testing various agricultural techniques, the study of soil structure and its water stability is obligatory. This will permit the development of a system of cultivation and agriculture through which the soil structure will be improved. Every effort must be made so that all field tests in agricultural techniques and fertilization are accompanied by study of the structure and physical properties as well as the chemical composition of soils in the dynamic cross-section.

In the territory of the Central Chernozem Oblasts', besides the chernozems and forest soils, there are sandy, saline, bog and flood-plain soils. On the whole, these soils occupy an area of several hundred thousand hectares. Wise cultivation and rational use of these soils will provide an additional yield of grain and other agricultural products by several million centners. However, the use of these soils in agriculture requires a basic improvement in them by various methods of melioration. Hence, it is necessary to expand and intensify the study of sandy, solonetz, bog and flood-plain soils, and to develop and provide a theoretical foundation for meliorative as well as agricultural practices, chemical and biological methods for improving these soils. This work must be joined in by all soil scientists and agricultural chemists as well as meliorators of the corresponding scientific institutions and organizations engaged supporting farm production.

Problems of erosion of soils, its consequences and control measures are of particular importance in the CCO. It is widespread, particularly within the limits of the central Russian uplands, and causes colossal damage to the national economy. Despite the particularly urgent nature of this problem, soil scientists of the CCO have as yet devoted little attention to it. It is necessary that all the basic forces be directed to a fundamental study of erosion, the consequences of erosion and the development of rational measures (including biological measures) for controlling it.

The following example will serve as convincing evidence of the colossal damage caused by erosion. In the eroded upper 20-cm layer of a typical chernozem the latter loses per hectare of area: 15,000 kg of nitrogen, 8,500 kg of phosphorous, 65,000 kg of potassium, 70,000 kg of calcium and 1000 kg of sulfur.[2] If it is kept in mind that the eroded soils occur over many thousands of hectares in the CCO, then the irrevocable loss of nutrients will be expressed in enormous figures. The work of studying so erosion and developing its measures must be joined (in addition to soil scientists and meliorators) by agronomists, forestry specialists, geographers, geologists, hydrologists, botanists and other specialists. The struggle against soil erosion must be a public effort.

On the basis of the foregoing problems and for the purpose of the most rapid execution of these problems it would be extremely advisable: in the immediate future to organize soil science divisions at the Scientific Research Institute of Agriculture of the Central Chernozem Belt imeni V. V. Dokuchayev (Kamennaya Steppe), at the Scientific Research Institute of Beet Culture (Ramon'), at the Scientific Research Institute of Northern Fruit Culture (Mischurinsk) and to establish soil science sections an agricultural chemical sections in all oblast' and zonal agricultural experiment stations; to organize a collective of soil scientists of the CCO so that all the most urgent problems of soil science will be solved as soon as possible and harmoniously, with consideration of the requirements of agricultural practice.

The soil scientists of Voronezh University conjointly with the soil scientists of the oblast' administrations of agriculture of the CCO must continue work in studying the genesis, classification and geography of soils, with soil regionalization and agrochemical characteristics thereof and must extend investigations in erosion to the site classification of soils. The soil scientists of the agricultural institutes (Voronezh, Kursk, Michurinsk) conjointly with the agricultural experimen stations must concentrate their efforts on the pro lems of agronomic and forest soil science as stat previously.

From this partial listing of the urgent problem requiring solution it follows that soil science is confronted with grandoise and honorable tasks. T their fulfillment all the efforts of soil scientists c ordinated by the V.V. Dokuchayev Soil Institute, SSSR, must be directed. The successful executio of these tasks will prove a worthy contribution in implementing the historic decisions of the Twent First Congress of the Communist Party of the Soviet Union in the field of agriculture.

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[2] S.S. Sobolev.

ERENNIAL GRASSES FOR RESTORING FERTILITY F CISCAUCASIAN IRRIGATED CHERNOZEMS

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Investigations by the North-Caucasian De-
rtment of the All-Union Forage Institute have
own that in irrigated zones the highest yields
e obtained from crops of pure alfalfa and
ass mixtures (alfalfa + rye-grass). During
first cropping year, alfalfa yields 96.7 cntr/
, and grass mixtures, 93.3 cntr/ha. With the
st cutting of grass mixture the proportion of
ass cover was about 50% of the total weight;
th the second cutting the proportion of grasses
considerably smaller, and in the third cutting
usually represents 15%-22% of the total.

Many investigations were conducted in the
SR to establish the effect of perennial grasses
the fertility of soils (3, 5, 6, 7, 8, 9, 10). As
t, none have determined the accumulation of
ganic matter and nitrogen in irrigated cher-
zems under perennial grasses. Between 1953
d 1955 an expedition of the V. V. Dokuchayev
il Institute, Academy of Sciences, USSR ob-
rved experiments on the accumulation of roots
nducted by the North-Caucasian Department
the All-Union Forage Institute in fields be-
nging to the Institute's Department, and in
kolkhoz of Koysug village in Bataysk dis-
ct of Rostov region.

Characterized by a considerably thick humic
yer (80-100 cm), the Ciscaucasian cherno-
ms have the texture of fine clay loams and
ntain 45%-66% of particle diameters <0.01
n. The field moisture capacity of a layer
20 cm thick is 30%, its wilting moisture
.4%. These soils have high total porosity
d good water permeability. There is no trace
salinity or water-logging, thus irrigation can
effected without any additional meliorative
easures. Once irrigated, these chernozems
among the best soils from the viewpoint of
oductivity, and high yields are obtained from
agricultural crop raised.

In 1952 experiments, the grasses were
illed on black fallows under panicgrass. In
der to irrigated and seed at the same time,
lges bordering the plots were thrown up 3.6
apart (the working distance of the seeders). The plots were flooded after each harvest at a rate of 500-800 m³. Three to four cuttings were harvested for each vegetation period. We measured the hay yield of irrigated and non-irrigated alfalfa, rye-grass and grass mixture crops during three years. Each year after the third cutting the roots contained in a 0-60 cm soil layer were weighed. In field experiments with grain crops, we counted the root residues from winter and spring grains during the bloom period.

The following procedure was applied for the grass root measurement. In three locations in grass plots, profiles were cut into the soil to a depth of 1 m. On three walls of a profile areas were selected from which the crop residues were cut with scissors; then a bottomless steel box 10 cm high, 10 cm long, 15 cm wide (its width corresponding to the distance between the rows) was inserted into the soil to a depth of 10 cm; thus the measured area covered 150 cm². After this the box containing the soil was carefully removed, and on the removed area another bottomless box was inserted into the soil to the same depth as the first. This operation was repeated nine times, and the amount of roots was determined for the following depths: 0-10 cm, 10-20 cm, 20-30 cm, 30-40 cm, 40-50 cm, and 50-60 cm. The roots contained in the soil samples were immediately washed in sieves with 0.25 mm meshes, and then dried until they were air-dry. Live and dead roots were measured together.

The grass roots of the first year were separated by hand and classified into diameters: large (>2 mm), medium (<1 to 2 mm), and small (<1 mm). This classification was discontinued in following years.

Table 1 shows the hay yields from plots where roots were measured.

After two years of cropping with irrigation, the alfalfa yield increased by four times, and that of grass mixture by two as compared with nonirrigated alfalfa. Pure and mixed alfalfa

Table 1

Hay yields by years

Treatment	Crop	Hay, cntr/ha			
		1953	1954	1955	Total
With irrigation	Alfalfa	102	108	95	305
	Alfalfa/rye-grass	90	105	101	290
	Rye-grass	68	47	25	140
Without irrigation	Alfalfa	37	24	—	—
	Alfalfa/rye-grass	48	31	22	101
	Rye-grass	32	20	13	65

were found to yield approximately the same crops, while rye-grass yielded two times less.

The results of root measurements of grasses and grain crops given in Table 2 indicate that the most intensive accumulation of root residues under perennial grasses occurs in the second year. In the following two cropping years a further increase in the amount of root residues is evident, but the accumulation rate is considerably slower. During all the years of measurement, there were more root residues with irrigation than without it. The bulk is accumulated during the second year of pure and mixed alfalfa cropping in the layer at 0-20 cm. The amounts of roots found in the soil at 0-60 cm differ only slightly from one another. The root to top weight ratio of perennial grasses differs sharply from that of the annual grain crops. Thus, for example, during the first cropping year with irrigation the alfalfa roots weighed 63% of the top growth; the second year weight increased to 71%; for the first and second year of mixed grass cropping, this ratio was 74% and 77%, respectively. The root content of perennial grasses is considerably higher without irrigation than with it; thus, the weight of alfalfa roots represents 154%-225% of the weight of top growth, that of mixed grass, 131%-193%, and that of rye-grass, 165%-225%.

In the case of grain crops, the root to hay weight ratios observed were substantially different: with irrigation, spring grain roots covered only 12% of the entire vegetation mass and 28% were covered without irrigation. According to our observations, the feather-grass steppes of the Rostov region accumulate 89.9 cntr/ha of roots in the layer at 0-60 cm; this is one and one-half times more than the amount accumulated by perennial grasses without irrigation.

Figure 1 shows the distribution of small, medium and large roots in the soil profile. As is seen, accumulation of rye-grass roots increases in non-irrigated zones. For irrigated lucerne and mixed grass, the relative amount of large roots increase, while those of mediu and small roots drop considerably. For mixe grass the percentage of small and medium ro is higher than for pure alfalfa. This increase is bound to affect the physical properties of th soil, and its aggregate and structural composition. In this connection we studied the physica properties of soils under perennial grasses of the second cropping year. As is seen from Table 3, plowed layers under perennial grass have become more compact through irrigation while in the plots the soil has maintained its porosity. Plowed layers under rye-grass became less compact than those under pure alfalfa or mixed grasses. Compaction of plowe layers during irrigation was accurately measured with Kachinskiy's compactometer. Thu soil resistance to compression was found to b 14.7 kg/cm² on cropland, 54.2 kg/cm² under rye-grass, and 81.5 kg/cm² under lucerne.

Total porosity of the root-containing layer soils is high, and it is higher under rye-grass than under alfalfa. An increased porosity of t subplowed layer is determined by its better structure in comparison to that of the plowed layer. According to our observations, under dry-land conditions plowed layers under pure or mixed alfalfa contain a larger quantity of water-stable aggregates than those under rye-grass. Apparently, rye-grass does not contri ute to the improvement of soil structure. Irr gation causes a sharp change in the development conditions of grasses and favors the structure formation in these soils. More water-stable aggregates have been found in plowed layers under rye-grass and grass mixtures, and less under alfalfa. It was found in all cases that the 20-30 cm layers and deeper contain more water-stable aggregates under alfalfa than under rye-grass or grass mixtures. Thus, the effect of grasses on soil structure is connected with the development of the root system, and it depends on both the characteristics of soil types and the condition of grass vegetation, and, above all, on the so

Table 2

Root accumulation, cntr/ha

Depth, cm	Alfalfa						Rye-grass						Alfalfa/rye-grass						Winter wheat		Spring wheat		Fthr.-gr. steppe
	No. of years in which used																		ir.	n/ir.	ir.	n/ir.	n/ir.
	1		2		3		1		2		3		1		2		3						
	ir.[a]	n/ir.	ir.	n/ir.	ir.	n/ir.	ir.	n/ir.	ir.	n/ir.	ir.	n/ir.	ir.	n/ir.	ir.	n/ir.	ir.	n/ir.					
0—10	39.1	29.1	49.8	32.8	47.2	—	34.8	35.4	30.0	30.0	17.3	—	36.3	29.1	38.2	32.8	57.3	—	10,2	7.8	5.1	4.2	48.2
10—20	13.0	11.8	13.2	8.6	20.5	—	11.6	8.0	8.2	7.0	10.7	—	15.6	11.8	11.2	8.6	27.1	—	1,7	3.6	2.2	2.2	21.2
20—30	5.4	7.0	3.9	3.0	8.6	—	6.6	4.2	2.9	3.9	3.9	—	7.8	7.0	7.4	3.0	17.3	—	1,9	1.8	2.1	0.7	8.7
30—40	3.5	4.3	4.4	6.0	4.6	—	4.2	3.2	1.2	1.9	2.3	—	2.5	4.3	2.4	6.0	7.0	—	0,7	1.5	1.3	0.5	4.6
40—50	2.0	3.0	3 0	1.2	4.6	—	2.1	2.4	1.5	1.6	2.3	—	2.4	3.0	3.3	1.2	5.8	—	0,7	1.7	—	—	4.2
50—60	1.9	1.8	3.1	3.0	5.0	—	2.1	2.6	1.0	1.4	1.4	—	2.8	1.8	1.9	3.0	3.3	—	0,7	1.1	—	—	3.0
0—60	65.0	57.0	77.4	54.6	90.6	—	61.3	55.8	44.8	45.3	37.9	—	67.4	57.0	64.4	54.6	117.8	—	15,9	17.5	10.7	7.6	89.9

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[a] ir. = irrigated; n/ir. = non-irrigated.

Table 3

Bulk density and total porosity of soils under grasses (Data by D. V. Fedorovskiy)

Depth, cm	Bulk density						Total porosity, volume %						Air availability, volume %					
	Irrigated			Non-irrigated			Irrigated			Non-irrigated			Irrigated			Non-irrigated		
	Spring wheat	Alfalfa	Rye-grass	Alfalfa	Rye-grass	Grass mixture	Spring wheat	Alfalfa	Rye-grass	Alfalfa	Rye-grass	Grass mixture	Spring wheat	Alfalfa	Rye-grass	Alfalfa	Rye-grass	Grass mixture
0—10	0,92	1,29	1,24	1,20	1,15	1,33	63	51	54	55	57	50	49	31	33	41	42	37
10—20	1,06	1,33	1,14	1,36	1,17	1,31	60	49	56	49	56	51	35	27	37	32	40	33
20—40	1,25	1,21	1,12	1,26	1,34	1,20	53	54	58	52	49	54	31	32	37	31	30	36
40—60	1,22	1,36	1,19	1,31	1,31	1,29	53	49	55	51	50	51	32	26	34	29	30	31

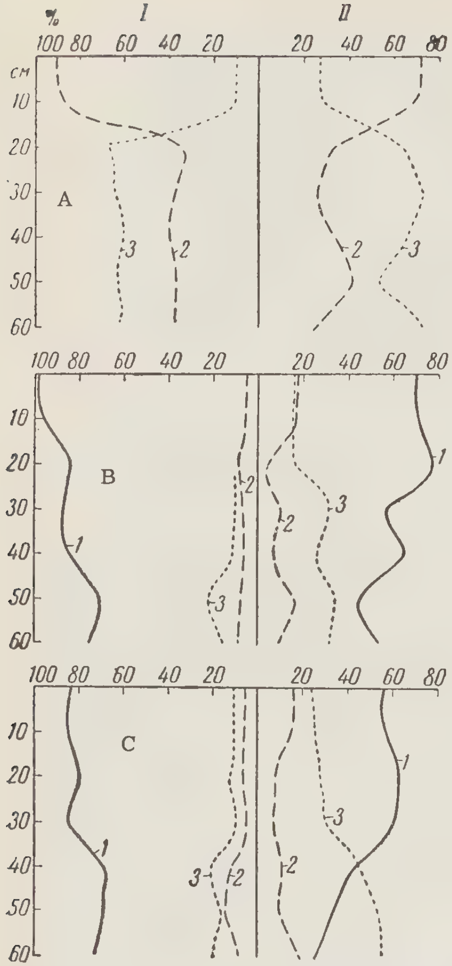

Fig. 1. - Distribution of perennial grass roots along the profile of irrigated soils.

I - irrigated; II - non-irrigated; A - rye-grass; B - alfalfa; C - alfalfa + rye-grass; 1 - large roots; 2 - medium roots; 3 - small roots.

moisture.

Data on the effect of perennial grasses on the chemical properties of irrigated Ciscaucasian chernozems are given in Table 4.

Soil samples for chemical analyses were taken at the same time as those for root measurements from the same soil profile at corresponding depths. Average mixed samples for analysis were taken from three different soil sections.

As is seen from Table 4 an increase of humus in soils under perennial grass crops was not observed during the period from the first to the third cropping year. Under pure or mixed alfalfa the total nitrogen content of the soil increased slightly along the entire profile, while

Table 4

Humus and total hydrolyzed nitrogen contents in irrigated soils under perennial grasses

Crop	Year	Humus, %				Nitrogen, %				Hydrolyzed nitrogen, mg/100 g of soil			
		Depth, cm											
		0–10	10–20	20–40	40–60	0–10	10–20	20–40	40–60	0–10	10–20	20–40	40–60
Alfalfa	1953	3.30	3.10	2.99	2.94	0.23	0.21	0.21	0.20	9.5	8.4	6.1	4.4
	1955	3.46	3.02	2.54	2.38	0.31	0.25	0.22	0.19	—	—	—	—
Grass-mix.	1953	3.36	3.30	3.20	3.10	0.23	0.21	0.19	0.19	8.4	6.7	6.1	5.6
	1955	3.21	2.95	2.79	2.65	0.23	0.25	0.22	0.19	—	—	—	—
Rye-grass	1953	3.36	3.30	3.25	—	0.23	0.21	0.20	—	8.4	8.4	7.8	—
	1955	3.30	3.20	3.05	2.94	0.21	0.20	0.18	0.15	—	—	—	—

under perennial grass (rye-grass) a certain decrease was noted. Under all the grasses we observed a high content of hydrolyzed nitrogen.

On the basis of the analyses, we calculated the nitrogen, phosphorus, potassium and calcium contents in root residues of perennial grasses per one hectare in the layer at 0-60 cm (Table 5).

Basically, nitrogen accumulates in root residues during the first two years of grasses. In the following years its content declines sharply. In the case of pure rye-grass a loss of nitrogen in root residues was found during the second and third cropping years. Apparently this is connected with the weight loss of rye-grass roots occurring during these years. For all the years, nitrogen accumulation in roots was considerably higher with irrigation than without it. This is connected with the fact that irrigated plots contain large amounts of roots.

In comparing the nitrogen, phosphorus and potassium content in root residues from the various grasses, attention should be paid to the relationship between the nutrients and the age of the grasses. As is seen from Table 5, nitrogen prevails over phosphorus and potassium in the case of pure legumes. With pure grasses this ratio grows narrower. Thus, the N:P:K ratio equals 5.6:1:1.8 for irrigated alfalfa, 3.8:1:1.8 for irrigated grass mixtures, and 1.6:1:1.5 for irrigated rye-grass. Without irrigation, the amount of potassium in root residues increases considerably.

According to our observations, nitrogen accumulation in perennial grass roots is substantially higher with irrigation than without it, and accumulation of root residues is in direct proportion with the hay crop. Some researchers reported hay crops of 60-70 cntr/ha without irrigation, whereas our experiments with irrigation yielded alfalfa crops of 210 cntr/ha with two-year croppings, and 305 cntr/ha after three years. Mixed grass crop yields, were of the same order.

On the basis of Peters' calculations, one metric ton of clover hay adds up to 10 kg of nitrogen to the soil, together with root and crop residues; our experiments have yielded considerably higher values for the first cropping year. Table 6 shows data on nitrogen accumulation in perennial grass roots per one metric ton of hay.

According to the data in Table 6 irrigated alfalfa added 15 kg of nitrogen per metric ton to the soil together with root residues, while alfalfa + rye-grass added 11.8 kg. During the second and third cropping years, the amount of nitrogen accumulated in the roots per one metric ton of hay diminishes sharply. Here

Table 5

Nitrogen phosphorus and potassium content of root residues, kg/ha

Crop	Cropping year	N		P_2O_5		K_2O		CaO	N:P:K ratio with irrigation			N:P:K ratio without irrigation		
		ir.[a]	n/ir.	ir.	n/ir.	ir.	n/ir.	ir.						
Alfalfa	First 1953	152	98	27	13	49	38	59	5.6	1	1.8	7.0	1	3
	Second 1954	182	92	32	12	58	36	70	5.7	1	1.8	7.6	1	3
	Third 1955	213	—	37	—	68	—	82	5.7	1	1.8	–	—	—
Alfalfa and Rye-grass	First 1953	108	98	28	9	51	46	34	3.8	1	1.8	10.8	1	5
	Second 1954	130	93	34	8	62	44	41	4.0	1	1.8	11.6	1	5.5
	Third 1955	188	—	49	—	89	—	60	3.8	1	1.7	6.8	1	5
Rye-grass	First 1953	39	34	23	5	36	25	38	1.6	1	1.5	6.8	1	5
	Second 1954	29	29	17	6	28	31	28	1.7	1	1.6	4.8	1	5
	Third 1955	24	—	14	—	22	—	23	1.7	1	1.5	—	—	—

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[a] ir. = irrigated; n/ir. = non-irrigated.

Table 6

Amount of nitrogen in roots of perennial grasses per metric ton of hay, kg

Crop	With irrigation		
	Cropping years		
	1	2	3
	1953	1954	1955
Alfalfa	15	8.3	6.9
Alfalfa and rye-gr.	11.8	6.1	6.5

we did not consider the nitrogen content of the stubble, which increases appreciably.

The amount of nitrogen biologically fixed by perennial grasses with or without irrigation, considering the amount contained in root and crop residues and in the hay of perennial grasses, as well as the amount of nitrogen from the air fixed by legumes, are shown in Table 7.

The amount of fixed nitrogen from the air by legumes has been computed by us as the difference between the nitrogen accumulated by legumes and by perennial grasses. According to these computations, pure alfalfa grown for two years on irrigated Ciscaucasian chernozem can fix up to 561 kg of nitrogen from the air, an grass mixtures (alfalfa + rye-grass), 284 kg. On the basis of Hopkins' and Peters' concept, the amount of fixed nitrogen from the air by legumes corresponds to two-thirds of the nitrogen contained in the entire crop; this value will be 524 kg for pure alfalfa, and 342 kg for mixed grass with irrigation and, respectively, 190 and 176 kg/ha, without irrigation. Thus, the values for fixed nitrogen from the air by legumes, computed by us as the difference between the nitrogen contained in legumes and in grasses, come fairly close to those of Peters. The amount of nitrogen fixed for pure alfalfa increases by one and one-half times as compare to mixed grasses. Here, too, irrigation plays an important role. Our experiments have shown that with irrigation, nitrogen fixation from the air by pure alfalfa increased by three times and that by mixed grasses by two times in comparison with non-irrigated crops. Half the nitrogen fixed from the air goes into the root and

Table 7

Biologically fixed nitrogen by perennial grasses

Crop	Hay crops for 2 cropping years	Amount of crop and root residues	Nitrogen accumulation, kg/ha			Biologically fixed nitrogen from the air by legumes, cntr/ha
	cntr/ha		In hay	In root and crop residues	Total	
			With irrigation			
Alfalfa	210	105	546	240	786	561
Alfalfa/rye-grass	195	109	327	185	512	284
Rye-grass	121	61	183	42	225	—
Spring wheat (seed)	19	25	62	14	76	—
Winter wheat (seed)	32	24	117	23	140	—
			Without irrigation			
Alfalfa	61	72	152	134	286	171
Alfalfa/rye-grass	79	81	133	133	266	151
Rye-grass	52	61	74	41	115	—
Spring wheat (seed)	5	8	26	11	37	—
Winter wheat (seed)	16	24	52	25	74	—

op residues, while the other half may return
o the soil in the form of manure. For pure
e-grass crops the nitrogen balance is nega-
e, both with and without irrigation, because
e quantity recovered by the soil does not
ver the losses through hay cropping. Hence,
en growing legumes with perennial grasses
der irrigation, a positive nitrogen balance is
tainable only if manure is properly accumu-
ed and stored, and properly applied in the
lds with crop rotation.

With irrigation, perennial grasses (and,
ainly, legumes) maintain soil fertility on a
gh level. Thus, in the sovkhoz "Red vege-
ble-grower" of the Bataysk district in the
scaucasian chernozem belt, 15 years of irri-
ting in vegetable crop rotation at high irri-
tion rates have not impaired either the nitro-
n or phosphorus content in the soil, because
alfa was included in the vegetable crop rota-
n. In areas of permanent irrigation, soils
ntained 3.5% humus, while in non-irrigated
nes they contained 3.7% (2).

In dark-chestnut soils and ordinary cherno-
ms of the Ukraine under grasses with per-
anent irrigation, the total available nutrient
mpounds humus and nitrogen continuously
covered approximately the same quantities
ntained in similar non-irrigated soils; this
evidence of the stabilization of nitrogen,
mus, and other elements in irrigated soils
der grass rotation (1).

Our soil analyses after plowing the land under
rennial grasses have shown that grasses have
t raised the total nitrogen content in the soil.
t, the yields of winter and spring wheat were
nsiderably higher than on preceding grain
d melon crops. Thus, with irrigation, the
nter wheat crops after grasses attained
cntr/ha, while on the preceding grain crop
y attained 16 cntr/ha; the spring wheat yielded
and 19 cntr/ha, respectively. Increased
ain yields after grasses are due to the im-
ovement of the nutrient regime of soils
used by the release of available nutrients
om the decomposition of root and stubble resi-
es. Figure 2 shows data on the dynamics of
rates in soils under winter and spring wheat
er grasses and the preceding grain crops.

As is seen from Figure 2, during any obser-
tion period the plowed grass area contains
re nitrate nitrogen than those preceded with
ain crops. Our experiments established a
her nitrate concentration in non-irrigated
nes than in irrigated ones, which apparent-
is due to less nitrogen uptake by plants in
soil moisture content (13%-15% without
igation). Improvement of the nitrogen regime
er grasses is confirmed by the process of
rogen uptake by plants. During the maximum
take period of winter wheat (from boot to ear
ge), the nitrogen content of the entire vegetation mass of the crop was six times higher after plowing of grasses than after plowing of grain crops; accordingly, the crops yielded 32 cntr/ha after grasses and 16 cntr/ha on the preceding grain crops.

The capacity of perennial grasses to assimilate difficulty soluble phosphates at an increased rate and to utilize phosphorus compounds from deeper soil layers intensifies the biological cycle of phosphorus in the soil. The difficulty available phosphates used by perennial grasses remain, at least in part, in the roots and are mineralized into compounds which become available to subsequent crops. The other part of the phosphates contained in hay may return to the soil in the form of manure. Table 5 shows that alfalfa roots add up to 37 kg/ha of P_2O_5 to the soil, while roots of mixed grasses add up to 49 kg/ha. In non-irrigated lands, perennial grasses decreases two to three times less phosphoric acid in the soil. If the phosphorus from root residues were fully utilized, its amount would be sufficient for two grain crops yielding 27 cntr each. Assuming, however, that two-thirds of all the phosphorus lost can return to the soil by manure application, the biological phosphate cycle enhanced by grasses will restitute the amounts of readily mineralizing phosphorus shown in Table 8.

As is seen from Table 8, the biological cycle of phosphates is more apparent in irrigated chernozems than in non-irrigated. Pure alfalfa crops provide an excellent example for this. It can be assumed that alfalfa mobilizes three times more soil phosphates than perennial grasses (rye-grass), and four to nine times more than made available by annual grain crops. In the biological cycle of phosphates, perennial legumes play a more important role than grass mixtures or perennial grain crops.

Figure 3 shows that during the entire vegetation period the content of available phosphorus compounds was higher in alfalfa than in preceding grain crops. Apparently, this is due to mineralization of organic matter from root and stubble during irrigation. Moreover, it should be noted that with increasing moisture from irrigation the amount of soluble soil phosphates increases as well. Different results were observed in non-irrigated alfalfa. In dry-farming conditions, soils strongly dried after perennial grass cropping. In these conditions mineralization of organic matter is slowed down. As a result, transition of organic phosphates into forms available to plants is stopped, and the subsequent crops become quite responsive to phosphorus fertilizers.

Observations on soil aeration and the concentration of carbon dioxide in soil air indicate that the intensity of carbon dioxide release depends on the agricultural crops and soil moisture. D'yakonova (4) found an intensive aeration

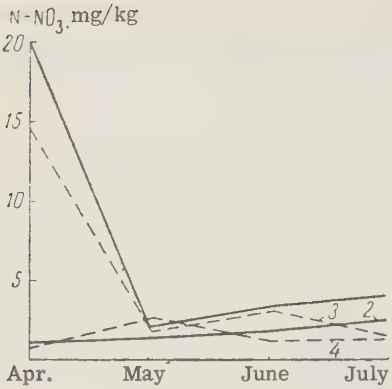

Fig. 2. - Dynamics of nitrates in soils under winter wheats. 1 - after grasses (0-20 cm); 2 - after grain crops (0-20 cm); 3 - after grasses (20-40 cm); 4 - after grain crops (20-40 cm).

of irrigated Ciscaucasian chernozems at the rate of 6.5-14.1 kg/ha/hour of CO_2 under alfalfa, and 7.0-11.0 kg/ha/hour of CO_2 under grain crops. Apparently, this depends on the different root systems, decomposition of dying roots, and root secretions. Growing amounts of carbon dioxide in soils under perennial grasses, as compared with grain and intertilled crops, appear to have some effect on the difficulty soluble calcium and magnesium phosphates, increasing their solubility and availability to plants.

Table 8

Biologically available soil phosphorus by perennial grasses

Crop	Removal of P_2O_5 by crop	Available P_2O_5 in soil, kg/ha		
		By root and stable residues	By manure	Total
With irrigation				
Alfalfa for 2 cropping years	142	60	94	154
Alfalfa and rye-grass, for cropping yrs.	113	49	74	123
Rye-grass, for 2 cropping years	63	25	42	67
Spring wheat	17	4	12	16
Winter wheat	37	5	24	29
Without irrigation				
Alfalfa for 2 cropping years	33	22	22	44
Alfalfa and rye-grass, for cropping yrs.	46	25	30	55
Rye-grass, for 2 cropping years	30	15	20	35
Spring wheat	6	4	4	8
Winter wheat	16	3	10	13

Conclusions

1. By irrigating the Ciscaucasian chernozem of Rostov region, high and consistent yields ar obtainable from perennial grass crops. For three years of cropping with irrigation, alfalfa yielded 305 cntr/ha of hay, alfalfa + rye-grass yielded 290 cntr/ha, and rye-grass, 140 cntr/ ha. Under the same conditions without irrigation, crop yields were three to four times less.

2. With irrigation, accumulations of alfalfa roots in the soil layer at 0-60 cm attain 90 cntr/ha, those of grass mixtures, 117 cntr/ha. Rye-grass and annual grain crops accumulate considerably less. Irrigation increases the percentage of large roots of perennial grasses and reduces that of medium and small roots. Mixed grass crops and pure grain crops have no advantages over pure legume crops in forma tion of soil structure in irrigated soils. A certain compaction of the plowed layer under perennial grasses has been observed with irrigation, especially in the case of alfalfa.

3. Basically, nitrogen accumulated in root residues during two years of life of perennial grasses. During the subsequent croppi years, nitrogen accumulated at considerably lower rates. The amounts of nitrogen fixed from the air by perennial legumes can be expressed by the following values: with irrigati

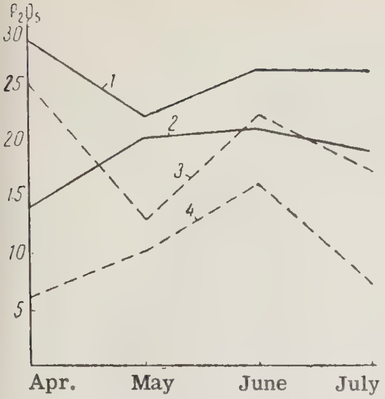

Fig. 3. - Dynamics of available phosphates in soils under winter wheats

1 - after grasses (0-20 cm); 2 - after grain crops (0-20 cm); 3 - after grasses (20-40 cm); 4 - after grain crops (20-40 cm).

ire alfalfa stand, 561 kg/ha; mixed grasses,
4 kg/ha; without irrigation, pure alfalfa
and, 171 kg/ha; mixed grasses, 151 kg/ha.
alf the nitrogen fixed from the air goes to
ot and stubble, while the other half can re-
rn to the soil in the form of manure.

4. Although perennial grasses have not sub-
antially increased the humus and nitrogen
ntent in the soil, they have improved the
trient regime for subsequent crops consid-
ably. At any time of observation, the alfalfa
ntained more nitrates after plowing than
edecessors. Accordingly, winter wheat
ops after alfalfa yielded 32 cntr/ha, and
cntr/ha on the preceding grain crops.

5. Perennial legumes enhance the biological
cle of phosphates in soils. It can be assumed
at irrigated alfalfa uses three times as much
il phosphates as perennial grain crops (rye-
ass) or annual grain crops.

Received February 29, 1959

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THE USE OF A LARGE-SCALE SOIL MAP IN AGRICULTURAL PRODUCTION

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The rational use of the land is one of the most important conditions for fulfilling the broad plan of increased agricultural production adopted by the 21st Congress of the Communist Party of the Soviet Union. Large-scale soil mapping is therefore important, since the soil map of a farm is the basic land-productivity document.

Large-scale soil maps often are not utilized fully, largely because soil scientists usually restrict themselves to description and classification of soil groups and make only slight mention in the explanatory notes of farm organization, crop rotations, and the planning of agricultural practices, etc., in relation to the features of the soils, in the sovkhoz or kolkhoz. Detailed soil studies are therefore insufficiently applied to the practical running of the farm. The need for collaboration between agriculturists and soil scientists has been shown by experience gained in the compilation of a soil map for a kolkhoz in the Moscow region.

This kolkhoz is a large diversified farm, mostly cropped to grain, covering an area of 6,600 ha in the extreme south of Moscow region.

The territory is part of the southern forest-steppe of the East European plain. Mean annual air temperature is approx. +4°C. The winter is comparatively severe, the mean January temperature being -16°C, and the summer warm, the mean July temperature being approximately 18-19°C. Annual precipitation is approximately 450-500 mm. The growing season varies between 173-179 days (mean dirunal temperature above +5°C), of which 139-140 days have a mean diurnal temperature above +10°C. This permits almost all the chernozem zone crops to be grown on the kolkhoz. The number of days with snow cover is about 144 and the thickness of the snow varies between 5 and 40 cm. Out in the open, however, the snow is often blown off slopes and prominent ridges into the gulleys and ravines and winter crops may be destroyed by frost.

The soils of the kolkhoz belong to the chernozem soil group. The soil map (Fig. 1) shows that the farm can be divided into approximately two parts (eastern and western) from the nature of the relief, the soils and the depth of the ground-water table. The western half of the territory, adjacent to the Polosna River, has a well-developed network of ravines and comparatively narrow prominent watersheds with gently or steeply sloping sides. The ground-water table here lies at 6-10 cm. Podzolized and leached chernozems are the main soils. These soils have the following features favorable to agriculture The humus horizon is 70-80 cm thick and the humus content of the plowed layer is approximately 6%-7%. The total nitrogen content is adequate at 0.35% in the upper horizon. The reaction of the soils is close to neutral. The total adsorbed cations is approximately 30-35 meq per 100 g of soil. The soil texture is fine clay loam. The most important separates are coarse silt and clay. This fact, plus the high humus and adsorbed calcium content, explains the capacity of these soils for well-developed structure and the low dispersion coefficient. The soils are highly por and water-permeable and the moisture capaci is considerable.

The high natural fertility of chernozems ca be accompanied in some years by low moistur supply. Measures to collect and conserve mo ture are therefore of importance.

The chernozems of the steep slopes stand out on the soil map against the general background of podzolized chernozems. These sectors are susceptible to erosion and should be excluded from the field crop rotations. If plowed they quickly lose their natural fertility and become abandoned area. They should the fore be used as pastures or put to hay. Finally, eroded podzolized chernozems have bee

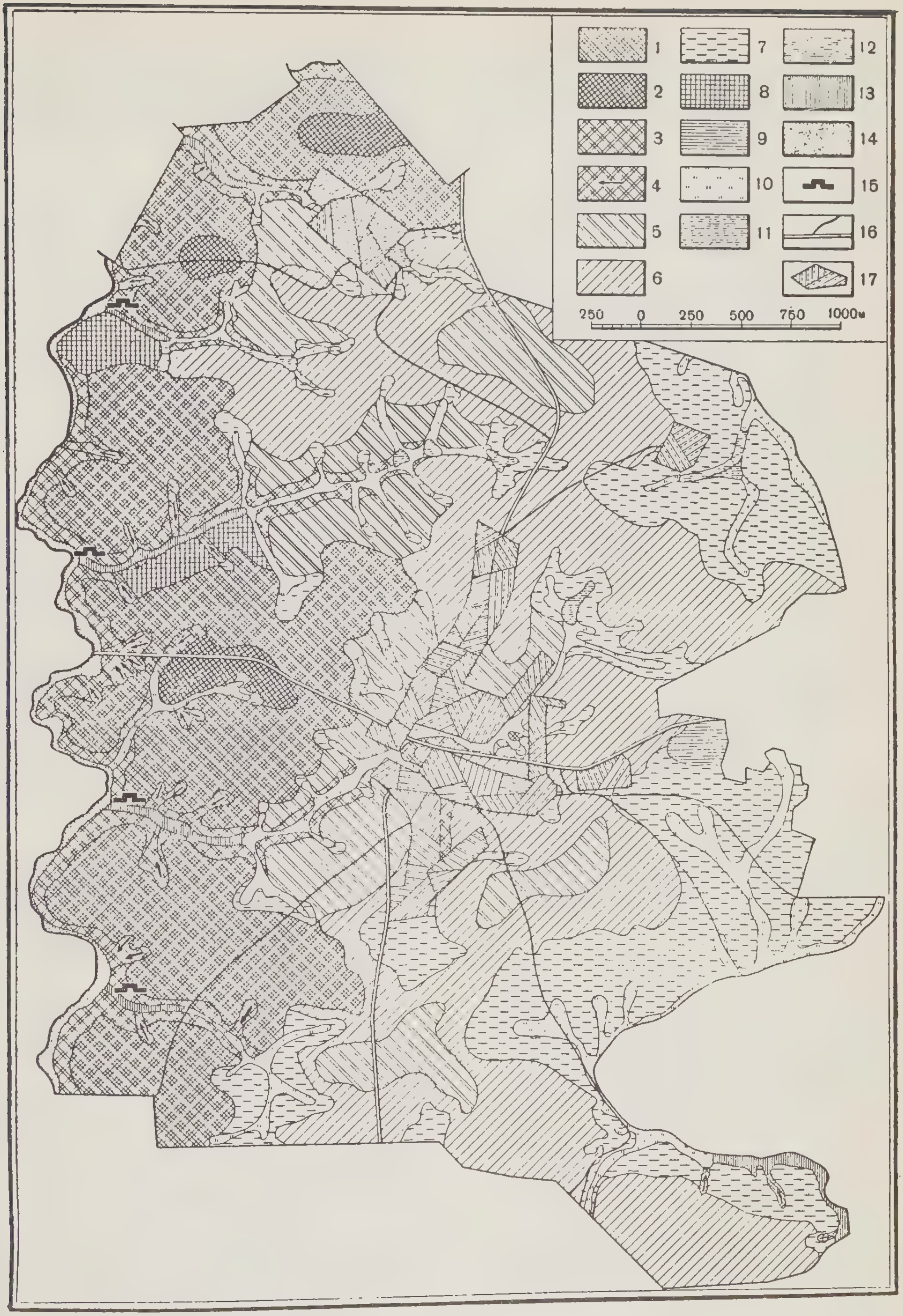

Fig. 1. - Soil map of one of the kolkhozes of Moscow region. Compiled by V.L. Andronikov and edited by Prof. Yu. A. Liverovskiy.

1 - medium humus, fine clay loam, podzolized chernozems; 2 - leached, medium humus, fine clay loam chernozems; 3 - fine clay loam podzolized chernozems on steep slopes; 4 - fine clay loam eroded chernozems; 5 - fine clay loam meadow-chernozems (with signs of podzolization); 6 - fine clay loam meadow-chernozem (ground-water table at 3 to 5-6 m); 7 - fine clay loam chernozem-meadow soils (ground-water table at 1.5-3 m); 8 - fine clay loam dark-grey forest soils; 9 - fine clay loam dark-grey forest gleys (ground-water table at 3-5 m); 10 - meadow-bog soils; 11 - humus-peat; 12 - peat-gley; 13 - fine clay loam sod gley soils; 14 - alluvial meadow (sod) river soils of varying textures; 15 - limestone outcrops; 16 - roads; 17 - inhabited areas.

distinguished on the cultivated slopes and bottoms at the upper ends of valleys. These areas should be left idle in grass to avoid further extension of erosional activity and the washing away of the fertile layers.

Broad flat watersheds, on which linear erosion has not yet penetrated, are a feature of the eastern half of the kolkhoz. Only ravines are found in the upper end of watersheds. Undulating ridges 250-300 m wide (at the crest) alternate with wide hollows. The ground-water table is quite shallow — approximately 1.5 m at the upper ends of the ravines and as much as 3-5 m on the watersheds. Meadow-chernozem and chernozem-meadow soils are the main soils. Like the chernozems, these soils are rich in nutrients and the humus and nitrogen content of the upper humus horizon often exceeds that of the chernozem. In early spring, however, these soils (especially chernozem-meadow) become unfavorably waterlogged and some crops suffer from excess moisture and the development of reduction processes. Shallow open ditches would help to drain these areas and increase fertility.

The eastern part of the territory is hydrologically more suited to forage crops while the western part can be used for crops with a lower moisture requirement.

The contours of dark-grey forest soils are encountered in the cultivated lands. These soils are poorer in nutrients than the podzolized chernozems and meadow chernozems. The humus content is approximately 5% and the thickness of the humus horizon and the content of adsorbed bases and total nitrogen are less. They are therefore more in need of organic and mineral fertilizers.

Land utilization in the kolkhoz can be better planned on a large-scale soil map, from which, in particular, the main trend and organization of the farm and the most rational balance of field, forage and vegetatable crop rotations can be decided and the most rational composition and alternation of crop be fixed.

The utilized land of the kolkhoz comprises 6651.94 ha, of which 5340 are cultivated (i. e., 80%), 401 ha are hay meadows, 502.95 ha are grazing and pasture and 42.0 ha are trees and shrubs. The manorial land, communal buildings and other lands (roads, ravines, waters, etc.) comprise 465.50 ha.

The type of agricultural kolkhoz, which is grain — meat — dairy, is dictated by the large expanse of utilized land, favorable soil and climatic factors, distance from railroads and highways and an inadequate labor force. Steers and rejected productive cattle can be fattened on the natural pastures of the ravines and gullies if the surface is improved. The rearing of pigs for bacon and meat, mainly on green and succulent forage should be an important factor in increasing meat production. The existing fine-wooled sheep and poultry flocks (a poultry farm of 10,000 laying hens) should be expanded.

The production of early potatoes, which are ready for harvest here 1-1/2 weeks earlier than in the northern districts of the region, could be extended to increase money income. The soil conditions (chernozems and meadow-chernozems) are favorable to the development of a new branch — commercial seed growing of crops which do not always ripen to seed in some districts (spring vetch and forage lupin). The growing of perennial legumes for seed, especially hybrid blue alfalfa which does not require large capital outlay or any marked increase in labor costs, can be an important source of income.

The fields for field and forage crop rotations should be so sited in relation to soil conditions as to obtain the best possible grain and forage crop per unit of area. Examination of existing land utilization in the kolkhoz shows that the existing distribution does not consider the soil conditions (Fig. 2). Suffice it to say that in a number of cases the forage rotation fields are located on dry areas of podzolized chernozems, while the main field crops are located o wet areas of chernozem-meadow soils in which the ground-water table lies near the surface an machine cultivation is often difficult.

We have therefore proposed a new plan for land utilization in the kolkhoz. This plan (Fig. 3) has been approved by the leadership and the farm organization. The essence of this new utilization of the land is as follows.

The soil map shows that the western area of kolkhoz, with its podzolized and leached chernozems and dark grey forest soils, is most suitable for field crop rotations. The eastern area, with its meadow-chernozem and chernozem-meadow soils should be used for fo age rotations with the emphasis on mixed legumes and grasses. The basis of division of different ratios of agricultural crops depends on soil moisture. V. R. Vil'yams (3) has determined the soil moisture requirement (as a percentage of total moisture capacity) as 30%-35% for grains, 70%-80% for perennial field grasses (legumes and grasses) and as much as 80%-90% for meadow seed grasses.

It seems desirable on this farm to establish hay-pasture rotations for the cattle and to use the grazing system (meadow-pasture rotations in Fig. 3). This system is known to increase labor productivity 1-1/2 times for grazing and to lower the cost of 1 kg of milk by 40% as compared with green fodder stall feeding (4). The yield of the pasture is also considerably

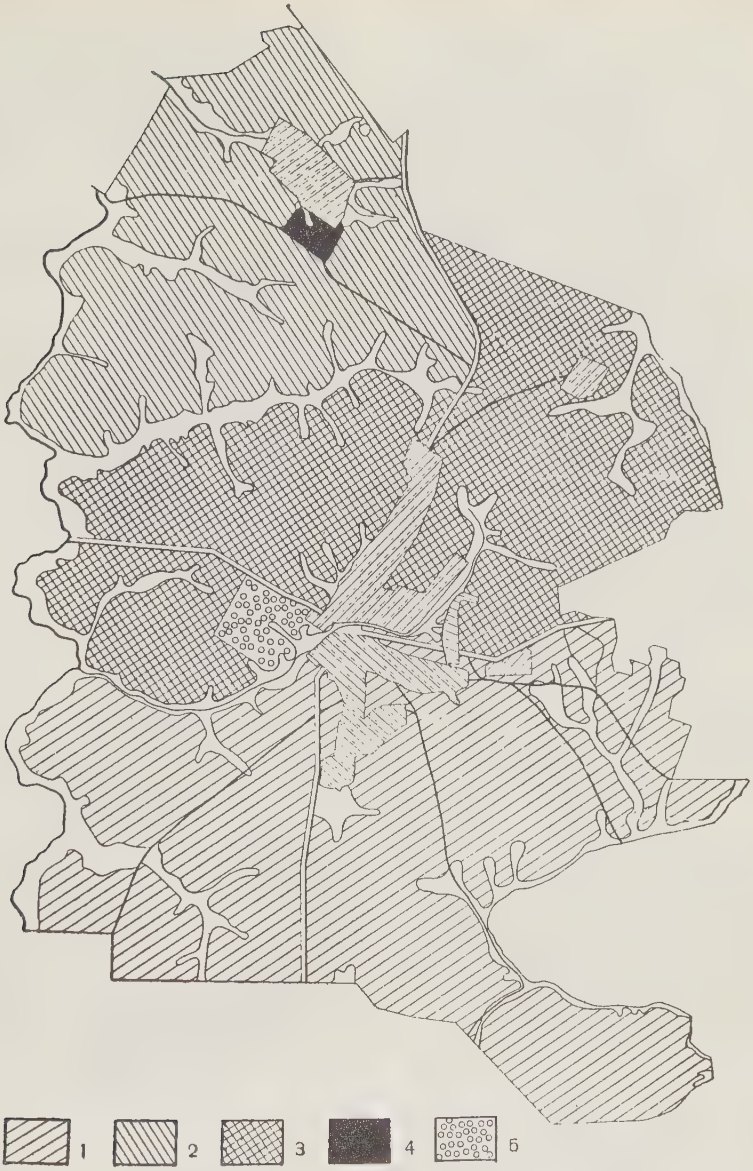

Fig. 2. - The existing land utilization in the kolkhoz.
1 - field crop rotation No. 1; 2 - field crop rotation No. 2; 3 - forage crop rotation; 4 - vegetable crop rotation; 5 - garden.

ncreased. A special farm rotation for the attle should be established to provide early reen forage, succulent forage and pasture for he young animals and a separate area for ilage for the larger animals. As shown on he sketch map (Fig. 3) it is situated near the nain kolkhoz livestock farm.

Rotations that will greatly increase the roportion of succulent and green forage in the ation, largely by roots, should be established ear the two pig farms and on the former MTS farmstead to boost meat production.

Almost all the plowlands of the kolkhoz are included at present in four crop rotations: I. ten year sequence on an area of 2247.4 ha (1, 2 — perennial grasses; 3 — winter crops; 4 — row crops; 5 — spring grains; 6 — fallow; 7 — winter crops; 8 — spring grains; 9 — bare fallow; 10 — winter crops with grass undercover; II. eight year sequence on an area of 1184.7 ha (1, 2 — perennial grasses; 3 — winter crops; 4 — row crops; 5 — spring

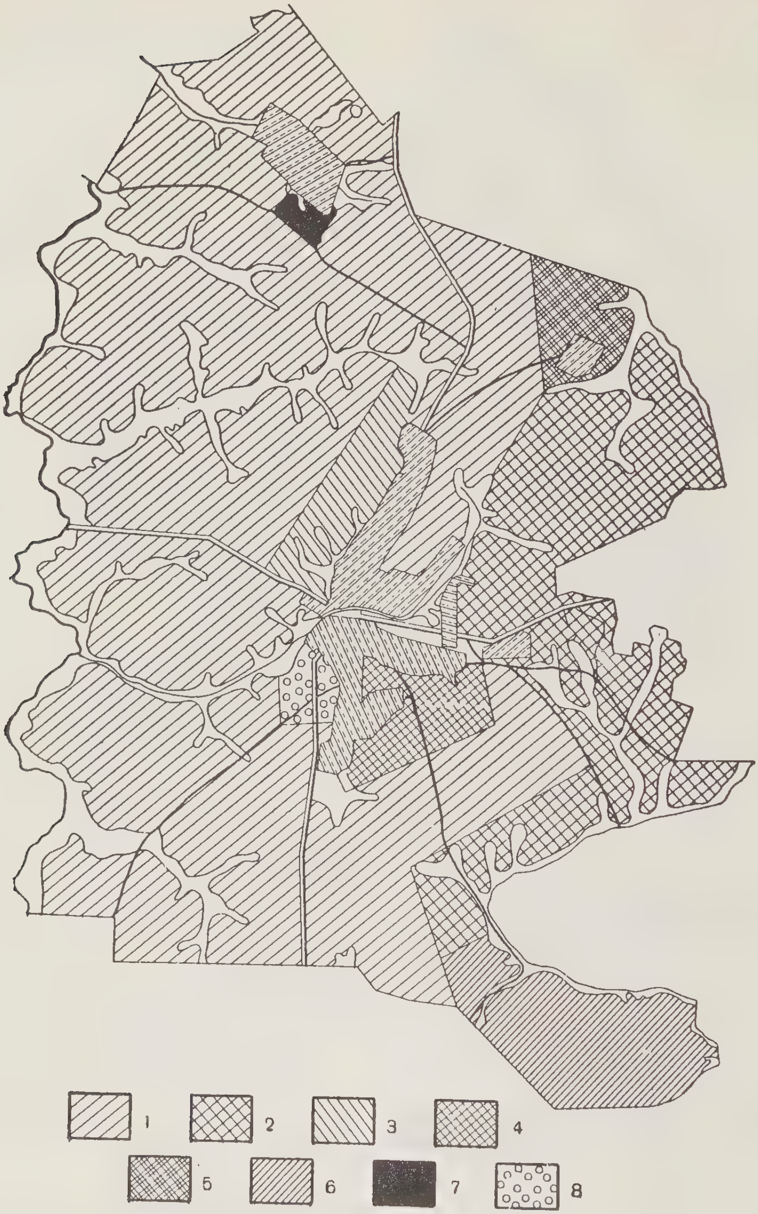

Fig. 3. - Projected land utilization considering soil conditions.

1 - field crop rotation; 2 - meadow-pasture (forage) crop rotation; 3 - livestock farm crop rotation for cattle; 4 - pig farm crop rotation No. 1; 5 - pig farm crop rotation No. 2; 6 - a remote plot temporarily in use as a three field grain rotation; 7 - vegetable crop rotation; 8 - garden.

grains; 6 — bare fallow; 7 — winter crops; 8 — spring grains with grass under crop); III — nine year sequence of forage on an area of 1768.3 ha (1-4 — perennial grasses for hay and grazing; 5 — winter crops; 6 — row crops; 7 — spring grains; 8 — green feed; 9 — winter crop with perennial grass undercover); IV. vegetable rotation on an area of 20.8 ha.

These rotation plans are not without shortcomings. Above all, the projected use of

rasses under winter crop means the loss of the
econd cut and of grass seeds. Since a winter
rop cannot use the surplus mineral nitrogen
ormed on the decomposition of the sod, a con-
iderable part may be leached from the soil
nd lost. In addition, in the southern area
f the region it has been shown in practice that
t is preferable to sow perennial grasses with
pring rather than winter crops (4).

The following rotations may be proposed,
earing in mind the soil and climatic conditions
nd the existing goal of the economy:

I. A ten year sequence on an area of 3681
a (podzolized and leached chernozems, dark
rey forest and meadow-chernozem soils) with
ne following crop rotations; 1 — spring
rains + grasses; 2-3 — grasses; 4 — row
rops (corn, potatoes); 5 — winter and spring
rains; 6 — fallow; 7 — winter crops; 8 —
pring crops; 9 — fallow; 10 — winter crops.

The introduction of one instead of the exist-
ng two field crop rotations considerably im-
roves the utilization of agricultural machin-
ry, by concentration and improved technical
ervice.

The following reasons can be advanced for
lanting row crops (especially corn) after
rass. These fields are usually less weedy,
ne soil structure is better and it "matures"
arlier, which is of importance in relation to
ne selection of the best sowing periods. Corn,
nore than any other crop, can use a great deal
f the nitrogen in nitrate form that occurs with
ecomposition of sod, and the protein content
f the top portion of the plant is also increased.
n the corn belt of the U. S. A. plowed grass is
ypically the best point in the rotations for
orn.

A three field grain sequence (bare fallow,
inter grain, spring grain) is being retained
or the present on the "Sapozhok" area (ex-
reme southeast of the territory). In the long
erm the meadow-pasture rotation may be in-
reased (by 332 ha) at the expense of this
rea as the number of cattle increases.

II. A meadow-pasture nine year sequence
n an area of 909 ha (mainly chernozem-mea-
ow and, in part, meadow-chernozem soils)
ith the following crop rotations: 1 — spring
rops + grasses; 2-6 — perennial hay and
asture grasses; 7 — spring grains; 8 — an-
ual mixed-grasses for green forage; 9 —
inter crops. The area may, as mentioned,
e increased from the "Sapozhok" area.

III. Farm crop rotation with cattle on 173
a (meadow-chernozems and podzolized cher-
ozems): alfalfa (or alfalfa + clover + fescue);
— corn; 3 — root forage crops and squashes;
— winter rye + winter vetch for green forage
and turnip or feed mixture (corn + maple pea + oats).

Alfalfa (or mixed grass) is used for 3-4 years. In this period the fields are interchanged 2-4 times. Once in 3-4 years alfalfa without cover (or mixed grass) is sown in field 4 in place of the stubble crops.

IV. Pig farm crop rotation 1 (central farmstead) on 130 ha (meadow-chernozem and chernozem-meadow soils): 1 — alfalfa; 2 — corn for silage and green forage; 3 — potato and squashes; 4 — vetch-pea-oat mixture for green forage. Alfalfa without cover is sown once in 3-4 years after the harvest. The alfalfa is used for 3-4 years, during which time the fields are interchanged 2-4 times. In addition a separate 10 ha plot is under Jerusalem artichoke. This crop rotation is also a green feed for the poultry farm.

V. Pig farm crop rotation 2 (on the former MTS farmstead) on 94 ha (chernozem-meadow soils). The crop rotation is the same as in IV. Once again there is a separate plot of 10 ha under Jerusalem artichoke. In addition to these field and forage rotations the existing vegetable rotation is retained on 20.8 ha. The model distribution of the crop rotations is shown on the sketch map (Fig. 3). There will be necessary changes in the structure of the sown area (Table 1) when the planned crop rotations are incorporated.

Sown areas under forage crops (especially perennial grasses) will be considerably increased at the expense of bare fallow and grain crops. It should be borne in mind, however, that until the grass fields and projected meadow-grazing and cattle farm rotations are fully introduced, i. e., for 3-4 years, the sown area of all grain crops can be increased by approximately 400 ha, initially and 100 ha at the close of the transition period and temporarily maintained at 2700-2400 ha. At the same time the conditions for larger grain harvests have been created by the improvement of the forerunning crops and an increase in locally prepared and mineral fertilizers. The average grain yield when the crop rotations are introduced has therefore been fixed at 18.8 cntr/ha and the gross harvest of grain at 4450 metric tons, excluding corn cobs of milk-wax ripeness.

The number of productive cattle can be considerably increased with this improvement of fodder resources. Calculations show that these crop rotations will supply sufficient rough forage, root crops, silage and green forage for a considerably increased communal forage requirement is 86% supplied by hay, legumes and legume-grass mixtures and only 14% is spring straw. The requirement for concentrates is met from home-produced grain.

Table 1

Structure of sown area, hectares

Crops	Sown area 1958	Plan tasks 1960	After intro of crop rotations (approx. 1965)
Plowland being worked	5323	5340	5340
Bare fallow	945	375	240
Total sown area	4378	4925	5100
Grains	2862	2352	2366
winter	1571	1234	1212
spring	1291	1118	1154
Technical crops	50	50	50
Potatoes	180	260	335
early	50	50	100
Vegetables	13	20	14
All feed	1273	2243	2335
crops corn for silage and green forage	350	400	470
Other silage	40	50	40
Annual grasses	412	290	384
Winter crop for additional green forage	—	35	43
Root crops and squashes	—	20	63[a]
Perennial grasses	471	1448	1335

[a] Including 20 ha of Jerusalem artichoke.

(or equivalent products). The consumption of grain can be reduced by increasing the corn cob silage in the feed ration of pigs.

The conditions exist for a further increase in the number of cattle and in meat production yield, if one allows for straw surpluses and the possibility of obtaining malt grains from a nearby distillery. In addition, the kolkhoz will be able to increase the communal herd in the next seven year plan period by acquiring personal cattle from the collective farmers. The kolkhoz plans to bring in 10-12,000 metric tons of malt grains a year and to bring the herd to 2000, including 1000 cows, by the end of the period. As a result, the draft plan envisages a production of 785 cntr of grain, 550 cntr of milk and 66 cntr of meat per 100 ha of agricultural land in 1965. The output of livestock products will have increased almmost threefold by comparison with the first year of the plan.

The use of a soil map is not confined to planning crop rotation. Within this framework the crops have to be distributed yearly in relation to the soil conditions they require. The soil scientist and the kolkhoz or sovkhoz agriculturist should once again have recourse to the soil map.

The main crops in this kolkhoz are winter and spring wheat, rye, oats, corn, buckwheat, potatoes, clover, alfalfa and vetch.

Winter and spring wheat cannot tolerate increased acidity and they should preferably be alloted to chernozem and meadow-chernozem soils. Liming can be useful if spring wheat is planted on podzolized chernozems and dark-grey forest soils.

Winter rye adapts itself quite well, even on soils of low natural fertility, with the exception of excessively moist soils. It is fairly resistant to increased acidity (pH 4.8-5.5). On this kolkhoz it can grow successfully on dark-grey forest soils and podzolized chernozems which have high natural fertility and a deep ground-water table. It is not suitable to plant winter rye for grain or chernozem-meadow soils with a shallow ground-water table.

Oats, which are very moisture-loving, can grow well on this kolkhoz on chernozem-meadow or meadow-chernozem soils.

Buckwheat should be planted here on well warmed southern slopes of meadow-chernozem soils (the ground water lies at a depth of 3-5 m ields on the warmer southern or south-estern slopes with deep plowed (up to 30 cm) eadow-chernozems are to be prefered for orn. From the data of the Moscow Plant reeding Station in the same district, the cli-atic conditions are favorable to the produc-on both the green silage of the corn and of cobs milk-wax ripeness. Corn can very well be used s a fallow crop when growing for silage and green dder.

The moist, cold, fine clay loams of the low-ing places (chernozem-meadow soils) are un-itable for potatoes, which must be grown in arm, well-fertilized, friable soils. These eas are usually excessively wet during the rvest in the fall and this makes mechanized fting difficult or impossible. Potatoes should erefore be planted on chernozem and meaow-ernozem soils.

The best grass mixture for the field crop tation is red late-flowering clover and tim-hy or meadow fescue. Red clover has a def-ite soil requirement and grows poorly on dry excessively wet, low-lying soils. It should erefore be grown on slightly acid (pH 5.5-6.5) eadow-chernozems or chernozems. Timothy ill grow successfully on excessively wet soils ith the ground-water table near the surface, t is normally sown in a mixture with clover, which case clover requirements determine e choice of soil.

Perennial forage rotation grasses, which ust contain alfalfa, should be sown on wet ernozem-meadow soils. The soil study ows that the carbonate horizon lies at a depth 90-120 cm, and this fact is extremely fav-able to the growth of alfalfa, which is also ore productive than clover and less liable frost damage.

Cultivating and fertilizing are important pects of measures to improve soil pro-ctivity. In this connection Williams wrote: f grassland agriculture is treated only as a rrect sequence of crops without a cultivating d fertilizing plan it cannot have any effect increasing yield" (3).

As can be seen from the soil map (Fig. 1), e texture of the kolkhoz soils is that of clay-lt fine-clay loams that are only slightly spersed. The dispersion factor in the humus rizon is 4-5, increasing in the cultivated rizon. The upper horizon is less aggre-ted, owing to continuous plowing. Being e-clay loams, the kolkhoz soils have a high oisture capacity and are quite heavy to work pecific resistance 0.53-0.97 kg/cm^2). Cher-zem-meadow soils in which the ground-water ble is close to the surface are noted for high oisture capacity, low aeration, unfavorable ermal properties (cold soils) and difficulty work.

If the soil is ripe when plowing, the plowing will be good and the harvests will consequently be increased for the lowest fuel consumption. Ripe soil is taken as that condition of the soil in which it is most easily worked to yield a crumb structure. Ripeness is a state that is mainly dependent on soil moisture. Good plowing with low specific resistance is to be obtained on the kolkhoz when relative wetness is 55%-75% (18%-25% of absolute moisture). Outside these limits the specific resistance of the soil will be greatly increased and the plowing will result in a cloddy or paddled state.

The periods at which podzolized chernozems in which the ground-water table is deep (western area) and meadow-chernozems in which it lies comparatively near the surface (eastern area, see Fig. 1) will be ready for plowing, harrowing and planting will therefore differ. Plowing should, for instance, start earlier on meadow-chernozem and especially on chernozem-meadow soils than on podzolized chernozems. Conversely, preparation for sowing and the sowing of spring crops should start earliest on podzolized chernozems. The agriculturist or kolkhoz chairman can most easily establish the boundaries of these soils from the soil map.

A planned fertilization for the fields is also essential to increase the harvests of all agricultural crops on the kolkhoz.[1] The first thing to be revealed by an analysis of the soil map and detailed soil study data is that the fields nearest to the inhabited points and livestock farms, that have been systematically manured, contain more nutrients than the distant fields.

The podzolized chernozems and meadow-chernozems shown on the soil map have considerable total nitrogen content (0.30%-0.43% or 7-10 metric tons per hectare in the cultivated horizon). As only an insignificant proportion of this nitrogen is hydrolyzed, application of nitrogenous fertilizers should yield good results.

The meadow-chernozems are best in available phosphates (8-15 mg of P_2O_5 per 100 g of soil [Kirsanov]). Still more available forms of phosphate (up to 20 mg per 100 g) are to be found in the chernozem-meadow and meadow-bog soils. Thus phosphates should only be used on these soils (45-60 kg/ha of P_2O_5) when growing crops with a high phosphate requirement (perennial legumes, root crops, corn for cobs, etc.). A dressing of 0.5 cntr/ha of granulated superphosphate in the rows when sowing is sufficient for grain crops. The podzolized chernozems of the western area of the kolkhoz are less well supplied with available phosphates (approximately

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[1] From data of Andronikov, Kovrigo, Nikanorovaya and Muzychkin.

8 mg per 100 g of soil). Phosphates must therefore be used with all crops. These soils are well supplied with available potassium (8-17 mg K_2O per 100 g). For the immediate future, only light applications of potash fertilizers, 45 kg/ha K_2O, need be given, mainly with silage crops (sunflower, corn, potatoes, root crops, etc. and legumes).

The soil reaction varies considerably between pH 4.6-6.5 of a salt extract. The meadow-chernozems (pH 5.0-6.5) are only slightly acid. The podzolized and dark-grey forest soils of the western area, on the other hand, have lower pH (5.3-4.6) and must be limed. The areas of cliffs and steep slopes shown on the soil maps are mainly limestone outcrops, which can be a good local source.

The soil map (Fig. 1) also shows peat deposits (the humus-peat and peat-gley contours on the map) estimated at 100,000 m^3. The production of 3-4 thousand metric tons of peat compost a year should be organized to utilize the peat beds as organic manure.

Great attention should be paid to the correct use of increased manuring. The kolkhoz has sufficient straw and can increase the litter allocation so as to produce 17,000-18,000 metric tons of manure from the increased number of cattle in 1965. This, plus the peat compost, will manure 1000 ha annually. Liquid manure must be used, since proper preparation and mechanized application will provide good additional nutrition for the grasses in the livestock farm and meadow-pasture rotations.

Measures to retain snow are of importance in increasing the productivity of these soils. A snow survey in 1958 emphasized the importance of retaining snow over winter crops on the southern and southwestern slopes of the valleys. These areas are, in fact, free of snow throughout the winter. This prevents the accumulation of water in the soil (most necessary here) and entails the possibility of frost damage to crops and bad wintering of grasses. Snow retention can be effected in various ways (snow piling plows, snow fences, leaving corn and sunflower stubble in the field, etc.).

An analysis of the soil map shows that it is not necessary to retain the snow on the eastern half of the meadow-chernozem and chernozem-meadow soils with weakly dissected relief and the ground-water table near the surface. Snow retention is much more important on the podzolized chernozems in the western half.

Thus the first use of a large scale soil map is for correct internal economic planning and the distribution of crop rotations in relation to the soils, but this should not exhaust its uses. Kolkhoz, sovkhoz and district agriculturists can use such maps to make the best possible distribution of crops in relation to their adaptability to heterogenous soil conditions. Areas in which the plowing, harrowing and sowing periods differ can be established from soil maps. The best distribution of fertilizing in relation to the different soils can also be established. Finally, the map can also be used for planning to control soil-erosion and selecting areas on which snow should be retained and forest belts planted.

Received May 6, 1959

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MPROVEMENT AND RATIONAL UTILIZATION OF LOWLAND ALINE SOILS OF THE SOUTHERN POLES'YE AND NORTHERN OREST—STEPPE OF THE UKRAINIAN SSR

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The saline soils of the Poles'ye are distrib- ed in the depressions, mainly on terraces of Dnepr, the Desna, and their tributaries. the majority of cases they have high poten- l fertility, conditioned by significant humus ntent (2.8%-6.2%), the accumulation of nitro- n in the form of nitrates and also other nu- ents, and by a favorable water regime, as a sult of the proximity of ground-water.

However, at the present time these soils used as pasture, and in part also as low- oductive hay land, with a yield of 3-5 cent- rs per hectare. This usage leads to compac- n of the upper soil layers, and, as a result, the drying and denudation of the surface, ich promotes rising flow of normal and dium-bicarbonate ground-water usually lying a depth of 1.5-2 m. The production of sodi- carbonate in ground-water, as has been own by the work of N. V. Orlovskiy and I. N. tipov-Karatayev and by others (1, 2), is nditioned not only by physicochemical proc- ses, but also in large part by the develop- nt of separate biochemical processes under erobic conditions — the result of the sulfate- ducing bacteria. The data of our own investi- ions support this thesis in connection with saline soils of the Poles'ye.

As far back as 1955 we varified the presence a significant accumulation of sodium carbonate l bicarbonates, both in the ground-water and the upper soil horizons, with the artificial eation of anaerobiosis — as is apparent from data of Table 1.

Analagous data on the raising of alkalinity creating anaerobiosis were obtained in an eriment with the very thick, low-humus ernozems of the Mironovskaya Experimental tion.

The data adduced here indicate a sharp rise ground-water alkalinity and the appearance normal carbonates, of which there were e prior to the experiments. Strengthening processes of sodium carbonate formation in the ground-water was favored by the addition of Rochelle's salt as energy material for the development of sulfate-reducing bacteria and also by the addition of sodium sulfate. In the upper soil horizons the process was qualitatively less, but even here, with the creation of anaerobiosis, total alkalinity was increased threefold. All the vessels upon unsealing exhibited strong concentrations of hydrogen sulfide, as shown by a strong smell.

The role of the sulfate-reducing process in sodium carbonate formation in the presence of initial sulfate salinization is generally known, and is well described in a summary monograph on the reclamation of saline lands (1); but up to now the quantitative aspect of the accumulation of sodium carbonate, and the role of this process in the increase of soil salinity where sodium sulfate is absent, have not been made clear.

Thus, with the use of these lands for pasture, where anaerobiosis is increased as the result of trampling, the natural process of salinization is accelerated significantly, and this often leads to the formation of sodium carbonate solonchak-like soils, and in extreme cases, to solonchaks. The often recommended use of such soils as permanent improved meadows is not rational, in view of the fact that with such use forage grasses deteriorate rapidly, and plots are converted to low-productive meadows. In addition, such use does not lead to a decrease of anaerobiosis and the process of sodium carbonate accumulation.

Hence the necessity of reworking the measures for improving lowland saline soils arises, not only from the point of view of getting a supplemental, and often insignificant, yield of agricultural crops, but mainly with the purpose of preventing ultimate progressive salinization.

In view of the excessive wetting and the structurless soils, there arises first of all the necessity of increasing aeration in the upper horizons. Therefore, great significance

Table 1

Changes in the composition of salts in ground-water and in sod saline soil at the "Peremoga" kolkhoz, Borodyanskiy Rayon, Kiyevskaya Oblast'

Scheme of experiment	Initial Data November 20, 1955				After conducting experiment with full stoppered vessels, March 28, 1956			% reduced sulfates
	pH	$CO_3^=$	HCO_3^-	$SO_4^=$	$CO_3^=$	HCO_3^-	$SO_4^=$	
Ground-water	7.2	None	$\frac{0.234}{3.84}$[a]	$\frac{0.001}{0.02}$	$\frac{0.043}{1.44}$	$\frac{0.351}{5.76}$	None	100
Ground-water + Rochelles salt 0.5%	7.4	"	$\frac{0.238}{3.90}$	$\frac{0.001}{0.02}$	None	$\frac{2.208}{36:20}$	"	100
Ground-water + Na_2SO_4 1.5%	7.2	"	$\frac{0.234}{3.90}$	$\frac{13.526}{281.8}$	$\frac{0.079}{2.64}$	$\frac{0.441}{7.23}$	$\frac{4.65}{96.9}$	—
Ground-water + Rochelles salt NA_2SO_4 1.5%	7.0	"	$\frac{0.238}{3.90}$	$\frac{13.526}{281.8}$	None	$\frac{1.337}{21.92}$	$\frac{5.23}{108.96}$	—
Meadow weakly saline horizon 0-20	7.5	Not det'd.	$\frac{0.018}{0.3}$	$\frac{0.007}{0.145}$	Not det'd.	$\frac{0.057}{0.93}$	None	100
Same soil + Na_2SO_4 0.5%	7.7	"	$\frac{0.018}{0.3}$	$\frac{0.345}{7.2}$	"	$\frac{0.059}{0.96}$	$\frac{0.123}{2.56}$	64.3
Sale soil + Rochelles salt 0.5%	7.7	"	$\frac{0.024}{0.4}$	$\frac{0.007}{0.145}$	"	$\frac{0.112}{1.84}$	None	100

[a] In the numerator, grams; in the denominator, meq in one liter of ground-water or in 100 grams of soil.

attaches to the question of the treatment of lowland soils, which appears as the leading factor in increasing aeration and preventing rise of salty ground-waters.

The experiments on the improvement of lowland saline soils of the Poles'ye were conducted by us at the Peremoga kolkhoz in the Borodyanskiy Rayon of Kiyevskaya Oblast', on carbonate, weakly solonchak-like, meadow, gley soils; and at the Lenin kolkhoz in Brovarskiy Rayon of the same oblast', on secondary-salinized-sod-medium podzolic gleyed soils with stronger carbonate-sulfate-chloride accumulation, where the amount of $SO_4^=$ attained 6.77, chloride 9.77 and total alkalinity 1 meq per 100 grams of salt crust in separate most strongly salinized samples.

After plowing up the plots we seeded them with forage beet and sugar beet, as the most salt-absorptive forms of vegetation.

The experiment with sugar beet was conducted in 1955, after earlier preliminary spring shallow plowing of sod and disking. The experiments with the forage beet were conducted in 1956 with spring plowing and preliminary shallow plowing of sod in the fall of 1955.

The results of treating the soil and applying fertilizers were studied on succeeding spring crops sown with perennial grasses, and on perennial grasses alone. Let's examine the results of the experiment of meadow-carbonate-weakly saline-gleyed soils (Tables 2, 3).

It is apparent from the data that in the first year of the experiment the greatest yield of sugar beet root on non-fertilized land was obtained by deep plowing with overturn of crust to 25-30 cm, where the yield, as compared with that of land plowed to the usual 16-18 cm, showed an increase of 75-76 centners per hectare, or 49%-50%. In the case of subsoil plowing, and also with Mal'tsev's method, the increase in yield was insignificant.

The high effectiveness of deep plowing with turnover of crust to 25-30 cm is explained by the fact that in soils which are excessively we and inclined to compaction there are created better conditions for aeration — conditions which promote a favorable development of anaerobic microorganisms, which, decomposing the organic material of the soil, guarantee better nutrition for plants during vegetative growth.

Such results from soil treatments are basically maintained during the second and third years following the treatments, as shown fro

Table 2

Yield of sugar beet root in 1955, centners per hecare[a]

Scheme of experiment. Depth of plowing, cm	Control	Manure 25 metric T/ha	$N_{45}P_{60}$	Manure 25 metric T/ha + gypsum 1.8 metric T/ha	$N_{45}P_{60}$ + gypsum + 1.8 metric T/ha
16–18	152	200	171	179	226
13–14 + soil depth to 10-12	171	214	205	176	169
25	228	211	189	201	218
30	227	218	229	197	210
45 (Mal'tsev's method)	185	205	218	177	170

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[a] The nitrogen was applied in the form of ammonium sulfate; phosphorus in the form of superphosphate.

Table 3

Yield of oats and hay, centners per hectare[a]

Scheme of experiment. Depth of plowing, cm	Control	Manure 25 metric T/ha	$N_{45}P_{60}$	Manure 25 metric T/ha + gypsum 1.8 metric T/ha	$N_{45}P_{60}$ + gypsum + 1.8 metric T/ha
Total mass of oats, 1956					
16–18	39.8	39.8	35.4	34.4	32.1
13–14 + soil depth to 10-12	41.1	40.7	33.3	36.8	30.7
25	41.2	41.7	34.9	37.7	25.5
30	43.7	42.7	32.8	33.3	27.4
45 (Mal'tsev's method)	41.5	39.9	33.4	32.3	29.8
Hay from perennial grasses, 1957					
16–18	21.2	28.2	21.1	24.1	31.4
13–14 + soil depth to 10-12	22.0	28.6	22.1	31.5	32.3
25	31.7	36.0	27.3	31.4	27.1
30	28.0	33.7	23.1	30.4	32.5
45 (method of Mal'tsev)	28.3	34.8	27.6	33.2	31.4

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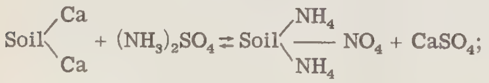
[a] The nitrogen was applied in the form of ammonium sulfate; the phosphorus as superphosphate.

ole 3, where the greatest yield of total mass oats and hay from perennial grass was ob- ned with deep inversion plowing to 25-30 cm. vever, the yield among different types of plow- as would be expected, evened out, as is nessed by the rapid compaction of the soil, as a result of which almost identical conditions of aeration are created in the upper horizons, apart from the influence of the type of treatment.

The influence of the treatment pointed out here is also basically characteristic of the fertilized plots, though in this case the yields are not the same. Thus in the first year manure was applied, the yield of sugar beet root in the case of 16-18 cm plowing was 43 centners per hectare; with Mal'tsev's method, 20 centners per hectare; while deep admixture of manure to 25-30 cm produced no additional yield. This is explained by the fact that with deep admixture, the mineralization of manure becomes difficult under conditions of significantly less aeration. In the second year after the addition of manure, also, there was no increased yield of total mass of oats.

In 1957 the effect of manure showed up distinctly. This is explained, obviously, by the fact that this year, when there was a smaller amount of precipitation and a lower level of ground-water (to 3 m, instead of 1.8 m in 1955-1956), the mineralization of the manure was increased, and this resulted in an increase of yield from perennial grasses, particularly those from soil with deep admixture of manure. With mineral fertilizers and gypsum, the picture changes. Thus, in the first year, with use of nitrogen in the form of ammonium sulfate, the sugar beet yield was increased in the case of the customary 16-18 cm plowing and also in the case of subsoil plowing and Mal'tsev's method; while with deep plowing, with inversion to 30 cm, there was no increase; and with inversion to 25 cm, an unfavorable result was also obtained. In other words, the effectiveness of fertilizers falls off in proportion to the depth at which they are added. The same pattern was observed in the case of added gypsum.

The absence of an effect from fertilizers and gypsum on deep plowed plots with turnover of crust to 25-30 cm is explained by the fact that with deep implantation of these substances in the soil under anaerobiotic conditions, sulfates are renewed by biological means, along with the formation of hydrogen sulfide, which is poisonous to vegetation. The process of sulfate renewal by anaerobiotic sulfate-reducing bacteria and the formation of hydrogen sulfide can be expressed briefly thus;



$$\text{Soil}\left\langle\begin{matrix}\text{Ca}\\ \text{Ca}\end{matrix}\right. + (NH_3)_2SO_4 \rightleftharpoons \text{Soil}\left\langle\begin{matrix}NH_4\\ \text{——}\\ NH_4\end{matrix}\right. NO_4 + CaSO_4;$$

$$CaSO_4 + 2C{=}2CO_2 + CaS;$$

$$CaS + CO_2 + H_2O{=}CaCO_3 + H_2S.$$

This process, as shown above, is supported by our laboratory experiment with ground-water and soil taken from the sugar beet area.

The reduction of sulfates and the poisoning of vegetation by hydrogen sulfide increased significantly in the second year following their introduction in view of the worsened aeration resulting from the abundance of precipitation during the first half of the year and in the spring. Th led to a decreased yield of total mass of oats plots with ammonium sulfate and gypsum, sinc the sulfate reduction could take place in the presence of excessive moisture, even in the upper horizons.

Several contradictory data for hay yield from perennial grasses on the plot with sulfates, applied in the form of ammonium sulfat and gypsum, are explained by the uneven relie of the section; in the lower portions, where th conditions favored reduction of sulfates, the yield was lower, but in higher portions a bette development of vegetation and increased yields were observed.

Along with the previous experiment, an analagous one was carried out in 1956 with the spring plowing, the shallow plowing of sod having been done in the fall of 1955. In this experiment potassium was applied, as well as nitrogen fertilizers — not in the form of ammonium sulfate, but as ammonium nitrate, as was done in the first experiment. Manure was added in a transformed, rather than in a straw form. The first crop was fodder sugar beet.

The yield of sugar beet root and oats is presented in Tables 4 and 5. From the data given it is evident that the greatest yield of fodder beet root in the non-fertilized plots, just as in the first experiment, was obtained from deep plowing with inversion to 25-30 cm, this being conditioned by the best aeration of soil under the given treatment. The same result was shown also in the second year after plowing, though in smaller degree.

On the plots where manure and mineral fertilizer were applied the yield of fodder sugar beet rose significantly in comparison with the non-fertilized plots for all types of treatment. This phenomenon is explained by the fact that the manure was applied in semi-decomposed form: consequently, a significant quantity of nutrients was present in it in easily assimilable form. Nitrogen was applied in the form of ammonium nitrate — in other words against a background of NP the amount of sulfates was lowered significantly. The application of sulfates into the soil in the form of gypsum in thi experiment led to reduced yield of sugar beet roots, obviously in view of the negative action of the hydrogen sulfide on the plants during the growing period.

The second year after the treatment of the soil, the role of deep plowing with inversion of soil to 25-30 cm, came to a minimum, with only an insignificant increase in oat yields.

Mineral fertilizers and manure, in their

Table 4

Yield of sugar beet root at the "Peremoga" kohkhoz in 1956, centners per hectare

Scheme of experiment. Depth of plowing, cm	Control	Manure 25 metric T/ha	$N_{45}P_{60}$	$N_{45}P_{60}$ N_{45}	Gypsum 1.9 metric T/ha	Manure 25 metric T/ha + gypsum 1.9 metric T/ha
16–18	300	376	351	348	276	331
13–14 + soil depth to 10–12						
25	270	366	396	364	300	317
30	323	439	433	372	319	460
45 (Mal'tsev's method)	337	403	404	392	281	319
	300	399	380	342	308	361

Table 5

Yield of oat grain on the "Peremoga" kolkhoz in 1957, centner per hectare

Scheme of experiment. Depth of plowing, cm	Control	Manure 25 metric T/ha	$N_{45}P_{60}$	$N_{45}P_{60}$ N_{45}	Gypsum 1.9 metric T/ha	Manure 25 metric T/ha + gypsum 1.9 metric T/ha
16–18	8.7	8.8	7.9	7.5	8.2	7.5
13–14 + soil depth to 10–12						
25	8.8	9.2	8.4	6.8	8.3	7.7
30	9.2	10.1	8.2	6.0	8.8	7.0
45 (Mal'tsev's method)	9.9	9.2	8.7	6.7	8.9	7.1
	8.9	8.5	7.2	5.8	8.8	7.1

idual effects, did not exert a positive role the increase of oat-grain yields, although development of plants where these substances e used was better than on the control plots.

The basic cause of the slight effect, or even ny residual effect at all, on the part of min- l fertilizers and manure on grain yield (the ld of straw was large), is the dryness of air sed by the high temperature during the t ten days of August (30-32°C); this leads he ripening of the oats and the formation of rior grains.

Gypsum did not exert substantial influence esidual effect on the decreasing grain yield of straw yield), since, in 1957, as a result he sharp lowering of water level (to 3 m as inst 1.6-1.8 m in 1955-1956), the soil in upper horizons was not excessively wet, the anaerobic processes of sulfate reduc- were considerably reinforced. The appli- ion of potassium to these soils, both in the first year (1956) and in residual-effect (1957), led to a decreased yield.

In the experiment on improvement of secondary salinized, sod-medium podzolic soils at the Lenin kolkhoz of Brovarskiy Rayon in Kiyevskaya Oblast' (Table 6), the greatest yield of sugar beets on all plots was obtained with deep plowing to 25-30 cm, which, as indicated previously, was accompanied by better aeration of the soil.

The absence of any negative effect from the application of gypsum to the soil in this experiment — and even its positive effect — with plowing to 25 cm and with subsoil tillage, was conditioned by the fact that these soils are significantly less wet as a result of the deeper level of the ground water during the course of the growing period (to 3 m): the reduction of sulfates by biological means shows up only in early spring when the level of the ground water is raised. The role of deep plowing and the

Table 6

Yield of fodder beet root and of root mass of the vetch-pea-oats mixture, at the Lenin kolkhoz, centners per hectare

Scheme of experiment. Depth of plowing, cm	Control	Manure 30 metric T/ha	$N_{45}P_{60}$	Gypsum 3.0 metric T/ha	Manture 30 metric T/ha gypsum 3.0 metric T/ha	$N_{45}P_{60}$ + gypsum 3.0 metric T/ha
Fodder beet root, 1956						
16–18	319	387	411	306	336	392
13–14 + soil depth to 10–12	239	421	402	342	336	320
25	331	387	445	459	395	411
45 (Mal'tsev's method)	323	359	390	380	370	413
Dry mass of vetch-pea-oats mixture, 1957[a]						
16–18	26.8	30.8	28.2	25.3	30.2	23.0
13–14 + soil depth to 10–12	21.5	30.1	24.1	24.7	28.0	22.0
25	28.4	31.8	28.2	30.0	33.0	29.4
45 (Mal'tsev's method)	25.8	27.2	27.1	20.4	30.2	18.8

[a] Harvest in the flowering period of peas.

application of fertilizers in this experiment in the second year shows up significantly, as is apparent from the yield data of the vetch-pea-oat mixture.

On saline soils on better drained areas of the northern forest-steppe of the Ukrainian SSR, the application of ammonium sulfate and gypsum shows a positive effect on the yield of agricultural craps. This is shown by data from the experiments of the Ukrainian Agricultural Research Institute (G. N. Sambur) conducted at the village of Bzov in Baryshevskiy Rayon, Kiyevskaya Oblast'.

As a result of plowing and cultivating agricultural crops on these lowland saline soils, progressive salinization was not only diminished, but, on the contrary, replaced by desalinization, particularly in the drained areas (ground-water level lower than 3 m) (Table 7). Thus, on secondary-salinized, sod-medium podzolic soils, as the result of plowing and planting of fodder sugar beet in the first year, the amount of water-soluble salts in the upper horizons of the soil is sharply diminished. The second year of utilization of these soils with a vetch-pea-oats mixture the desalinization of the soils continued.

From the data given it is evident that alkalinity, the content of water-soluble salts (chlorides and sulfates of sodium), has diminished sharply in comparison with the initial content (May 5, 1956), especially in the uppe soil horizons, as a result of plowing and sow agricultural crops on these soils.

On a long-abandoned plot adjacent to the e periment, the amount of water soluble elements increased basically towards the upper soil horizons. This indicates progressive salinization.

Conclusions

1. Ground-waters, containing bicarbonate and carbonates of sodium, and lying at a dep of 1.5-3.0 meters from the surface, are the source of the salts found in the saline soils c the Ukrainian Poles'ye. The formation of sc carbonate in these soils is conditioned for th most part by the development of the sulfate-reducing process in the presence of strongly developed anaerobiosis.

The utilization of these soils at the preser

Table 7

Change in the composition of water-soluble materials in secondary-salinized, sod-medium podzolic gleyed soils as a result of the utilization of them during the course of two years under agricultural cultures, 1956-1957

Experiment treatment Depth of plowing, cm	Depth, cm	$CO_3^=$ in%		Anions and cations, meq/100 g soil									
				$HCO_3^=$		Cl^-		$SO_4^=$		$Ca^{++}+Mg^{+++}$		Na^+ by difference	
		May 9, 1956	Aug. 2, 1957	May 9	Aug. 2	May 9	Aug. 2	May 9	Aug. 2	May 9	Aug. 2	May 9	Aug. 2
16–18 Control	0–2	Traces		0.60	0.24	0.30	0.06	Traces	0.06	0.61	0.34	0.29	0.02
	2–20	"	"	0.44	0.48	0.24	0.04	None	0.08	0.54	0.24	0.14	0.36
	20–30	"	"	0.39	0.34	0.22	0.08	"	0.19	0.60	0.29	0.01	0.32
	30–40	"	None	0.36	0.32	0.24	0.08	"	0.14	0.55	0.34	0.05	0.20
16–18 Gypsum 3.0 metric T/ha	0–2	None		0.56	0.20	0.98	0.02	3.85	0.21	1.82	0.46	3.57	None
	2–20	"	"	0.39	0.18	0.32	0.04	0.71	0.50	0.78	0.57	0.64	0.15
	20–30	"	"	0.36	0.28	0.32	0.04	Traces	0.07	0.68	0.39	None	
	30–40	"	"	0.39	0.24	0.56	0.04	None	0.05	1.30	0.33	"	"
25. Control	0–2	0.003	0.004	1.07	0.44	0.05	0.06	None	0.06	0.78	0.51	0.85	0.01
	2–20	None	0.002	0.48	0.38	0.16	0.04	"	0.08	0.63	0.50	None	
	20–30	"	None	0.48	0.32	0.17	0.04	Traces	0.04	0.72	0.45	"	"
	30–40	"	"	0.40	0.32	0.47	0.04	None	0.06	0.82	0.41	0.05	"
25. Vetch. 3.0 metric T/ha	0–2	0.004	0.001	0.84	0.36	0.36	0.04	0.10	0.02	0.86	0.47	0.40	"
	2–20	Traces	0.001	0.40	0.28	0.24	0.20	0.06	0.03	2.26	0.59	None	
	20–30	None		0.38	0.34	0.26	0.08	0.10	0.11	1.11	0.47	"	0.06
	30–40	"	"	0.38	0.34	0.18	0.08	None	0.07	0.73	0.45	"	0.04
Green area adjacent to experiment	0–2	Not detd.	0.007	Not detd.	0.96	Not detd.	0.19	Not detd.	0.38	Not detd.	0.29	Not detd.	1.24
	2–20	"	0.001	"	0.42	"	0.50	"	0.79	"	0.46	"	1.25
	20–30	"	0.001	"	0.32	"	0.36	"	0.69	"	0.63	"	0.74
	30–40	"	0.001	"	0.34	"	0.12	"	0.69	"	0.33	"	0.82

Note: In the columns dated May 9, figures represent the initial quantity of salt before the experiment of spring-1956, while those dated August 9 represent the quantity of salts after a two-year utilization of the soils for agricultural crops. Samples were taken in both periods from the same experimental sites.

time for pasture leads to compaction and contraction of capillaries, and to denudation of the surface; consequently, also, to a strengthening of the rise of ground-water flow. In this situation, the naturally slow salinization is accelerated, and often leads to the formation of sodium solonchaks.

2. At the present time the basic factor which limits the use of weakly saline, lowland soils of comparatively high potential fertility, is the decreased aeration of such soils, brought on by their structureless state and excessive moisture resulting from the proximity of ground-water.

3. Field experiment has established that the most effective means of raising the fertility of these soils is deep plowing, with inversion of soil to 25-30 cm, by which the very best aeration is achieved. The usual inversion of 16-18 cm, subsoil plowing, and plowing by Mal'tsev's method, are less effective.

The equalization of yield of the oats and the vetch-pea-oats mixture, among the types of plowing, observed the second year after their introduction, indicates a very rapid salinization of the soils, and the creation of almost identical conditions of aeration independent of the type of plowing. It is therefore obviously necessary to conduct deep plowing every year, with inversion of soil surface for every crop of the field period of meadow crop rotation.

4. Manure should not be admixed deeply, and should be used in semi-decomposed form, in the case of deep working of the soil.

Nitrogen fertilizers in conjunction with superphosphates on excessively-wet, weakly saline meadow gley soils should be applied in the form of ammonium nitrate, since, their application in the sulfate form leads to lowering of yield, as a result of the poisoning of vegetation by the products of biochemical reduction of sulfates (hydrogen sulfides and other sulfides).

5. Adding gypsum in conjunction with deep plowing with inversion of sod is an effective measure for improving less excessive wet soils.

The application of gypsum to excessively-wet soils, like the application of ammonium sulfate, leads to reduced yield.

6. The first year these lands were plowed, it was necessary to sow fodder or sugar beet as the more stable and productive crops. In addition, their cultivation leads to a supplemental breaking-up of sod, while cultivating the soil in the growing period leads to a decreasing upward flow of ground water and a diminution of salinization.

Received February 20, 1959

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ADSORPTION OF RADIOSTRONTIUM BY SOME SOILS AND SOIL MATERIALS

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From the physiological point of view, the most hazardous of the radioactive fission products is strontium-90. Its production in uranium fission is considerable, amounting to 5.13%. Its long half-life (27 years) and retention in the skeleton of men and animals (especially growing organisms) necessitates the careful study of radiostrontium movement in soils, where it may occur as a result of atomic accidents or atomic explosions (8).

It is known from geochemistry that strontium is usually associated with calcium in its movement in the earth's crust (10, 14). This fact indicates the necessity for a detailed study of the effect of calcium ions on adsorption of microquantities of strontium on natural sorbents.

There is little work reported on strontium-90 sorption by natural materials. It has been shown (11) that radiostrontium is first adsorbed from a solution filtering through sand, and is washed out upon further percolation with the same solution. The following series was established for several cations displacing strontium-89, 90 from soils (16):

$$Cs^+ > NH_4^+ = K^+ > Na^+ > Li^+.$$

Partially calcined dolomite adsorbed 90%-98% of radiostrontium from a non-saline solution (0.2 g sorbent in 50 ml solution) (1). Numerous papers (6, 12, 13, 15, 17) have dealt with adsorption of mixed fission products, including strontium-90, by natural materials. In this respect, different soil types, montmorillonitic and kaolinitic clays, sand, nepheline syenite, etc., have been studied. These investigations showed that micro-quantities of strontium in the presence of other cations, particularly H^+, are poorly adsorbed. In no case has irreversible adsorption of radiostrontium been observed. However, some data shows that adding lime, or even humus, to acid soils brings about tighter bonding of fission products (5, 7). The complete mechanism of this bonding is not yet clear.

In this study, we attempted to include the widest possible range of natural sorbents, mainly pure minerals found in soils, in order to determine their adsorption of microquantities of strontium under uniform experimental conditions. Chiefly, minerals of the calcite, feldspar, montmorillonite, gypsum, and mica groups were studied. In addition, such sorbents as peat, peat ash, lignite, and some others were studied. The experiments were carried out in four solutions (Table 1).

The first two solutions contained different amounts of carrier-free strontium-89-90, without any added salt. Stable strontium chlor ides was added to the third solution, and calci um chloride to the fourth. The concentrations of the radioactive isotopes were $10^{-7} - 10^{-9}$ $\underline{N}$

The experimental method was as follows: 1 g sorbent was shaken with 50 ml solution unt equilibrium was reached, which sometimes re quired several days. Then samples were with drawn for radioactivity measurements. Since strontium-90 has a radioactive daughter, yttrium-90, the samples were held 14-15 days in order to establish radioactive equilibrium between $Sr^{90}-Y^{90}$. Beta-ray counting of stron tium-yttrium was done in the usual ways (9) on a B-2 apparatus using a 1.2 mg/cm² mica window. The sorbents had previously been ground and 80-100 mesh fractions selected, but some — montmorillonite, kaolinite, peat ash, and dickite — were finer than this.

The results are presented in Tables 2 and where K signifies the adsorption of radiostron tium in percent of the original amount in solution. The experimental error did not exceed 2%-3%.

Montmorillonitic clays of different origin are designed in the tables by letters: A — Kyzyl-SP (Kazakhstan), B — Oglanlinsk (Turk men SSR), C — Kil (Crimea), D — Askangel' (Georgia). Equilibrium pH values of the solutions varied from 7 to 9.

Table 1

Composition of initial solutions (pH 8-9)

Solubion No.	Concentration of stable strontium, meq/1	Activity of strontium-89, 90; curies/1	Concentration of calcium, meq/1
1	0	1.5×10^{-6}	0
2	0	1.5×10^{-6}	0
3	5	8×10^{-6}	0
4	0	8×10^{-6}	5

Translator's note: According to statements in the text, I believe the activity of strontium-89, 90 in solution No. 2 was actually 8 microcuries per liter instead of 1.5. However, there is no explicit statement to this effect.

Table 2

Adsorption of radiostrontium by some natural silicates and aluminosilicates

Group	Mineral	Soln. No.	Adsorption K, %	Group	Mineral	Soln. No.	Adsorption K, %	Group	Mineral	Soln. No.	Adsorption K, %
Hydrous mica	Glauconite	1	83	Montmorillonite	A[a]	1	99.9	Quartz	Quartz	1	20
		2	78			2	99			2	19
		3	67			3	99			3	8
		4	70			4	98			4	6
	Vermiculite	1	88		B	1	99.9	Nepheline syenite (rock)	Mariupolite	1	86
		2	91			2	99.9			2	92
		3	80			3	98			3	50
		4	82			4	99			4	54
Mica	Biotite	1	72		C	1	92		Khibinite	1	70
		2	81			2	95			2	72
		3	60			3	85			3	35
		4	72			4	76			4	29
	Muscovite	1	87		D	1	98	Nepheline	Nepheline	1	71
		2	85			2	99			2	69
		3	71			3	97			3	35
		4	80			4	92			4	40
Serpentine-kaolinite	Superpentine	1	66	Zeolite	Natrolite	1	60	Asbestos	Asbestos	1	56
		2	63			2	66			2	48
		3	34			3	29			3	46
		4	36			4	36			4	41
	Kaolinite	1	68		Stilbite	1	22	Feldspar	Albite	1	27
		2	67			2	27			2	32
		3	41			3	23			3	4.5
		4	40			4	12			4	5.5
	Dickite	1	38	Halloysite	Halloysite	1	88		Oligoclase	1	39
		2	29			2	89			2	37
		3	19			3	74			3	18
		4	20			4	72			4	24
Talc-pyrophyllite	Talc	1	18	Pyroxene	Aegirite	1	50		Labradorite	1	50
		2	21			2	60			2	61
		3	16			3	33			3	34
		4	15			4	21			4	35
	Pyrophyllite	1	14		Diopside	1	47		Microcline	1	28
		2	14			3	47			2	24
		3	7			3	20			3	10
		4	6			4	19			4	11
Kyanite	Kyanite	1	44	Amphibole	Hornblende	1	45	—	—	—	—
		2	44			2	48	—	—	—	—
		3	31			3	24	—	—	—	—
		4	22			4	23	—	—	—	—

---

[a] Explanation given in the text.

Table 3

Adsorption of radiostrontium by some minerals other than silicates and aluminosilicates

Group	Mineral	Soln. No.	Adsorption K, %	Group	Mineral	Soln. No.	Adsorption K, %
Calcite	Magnesite	1 2 3 4	34 33 22 24	Materials of organic origin	Peat	1 2 3 4	93 92 86 75
	Calcite	1 2 3 4	40 48 43 21		Peat ash	1 2 3 4	55 54 42 39
	Limestone (rock)	1 2 3 4	45 49 38 29		Lignite	1 2 3 4	60 58 42 37
	Aragonite	1 2 3 4	39 40 29 27		Diatomaceous earth	1 2 3 4	58 60 40 39
	Iceland spar	1 2 3 4	33 38 28 20	Covellite	Covellite	1 2 3 4	2 4 0 1
	Ankerite	1 2 3 4	35 40 25 15	Lepido-creta-goethite	Limonite	1 2 3 4	50 48 37 25
	Dolomite	1 2 3 4	30 28 20 21		Hydrogoethite	1 2 3 4	70 68 54 49
Gypsum	Anhydrite	1 2 3 4	44 39 37 25	Apatite	Phosphorite	1 2 3 4	96 94 92 89
	Gypsum—alabaster	1 2 4 4	48 50 40 16		Fluorapatite	1 2 3 4	61 59 32 31
Rutile	Pyrolusite	1 2 3 4	99.9 99 94 95	Gibsite	Gibbsite	1 2 3 4	58 57 37 22
Corundum—ilmenite	Hematite	1 2 3 4	28 20 20 22	— — — —	— — — —	— — — —	— — — —

Table 4

Exchange capacity of sorbents (determined with $SrCl_2$)

Mineral	Microcline	Dolomite	Phosphorite	Bauxite	Muscovite	Vermiculite	Kaolinite	Apatite	Montmorillonite		
									A[a]	B	C
xchange in mg-meq per 100 g	1	2	27	36.2	14	104	22	8.4	102	98	108

[a] Explanation given in the text.

he results show no chemical specificity adiostrontium adsorption by any of the erals investigated. Radiostrontium was adsorbed by montmorillonite, kaolinite, s, hydrous micas, pyrolusite, halloysite, , phosphorite, and nepheline syenite, i. e., e sorbents which in general possess large ange capacities, as may be seen in Table

xchange capacities of the minerals were rmined by shaking a sample of sorbent with tion containing a large amount of stable ntium at pH 7-8. Strontium concentrations measured using radiostrontium 89, 90.

he abundant soil minerals of the calcite, spar, quartz, and gypsum groups do not rb strontium significantly. Therefore, ostrontium adsorption by the mineral part ils is determined by the clay minerals, h are usually found in a finely divided state, ntrast to the other minerals.

addition, it follows from Tables 2 and 3 al solutions 3 and 4) that the presence lcium in concentrations approximately l to those in river waters sharply reduces ostrontium adsorption. Thus, radiostron- falling on the soil will move into the 's mantle under the influence of the cal- ions usually occurring in river and nd-waters.

he mechanism of radiostrontium adsorp- by the minerals investigated is believed volve ionic exchange, since most of the rals chosen exhibit ionic exchange proper- This has been convincingly shown by ral authors in earlier publications (2, 3, 4).

e could not detect any effect on the level diostrontium activity in solution of the de- of its sorption (Tables 2 and 3, initial ions 1 and 2).

Conclusions

1. Adsorption of the radioactive fission product strontium was studied with fifty natural materials frequently found in soils, from solutions containing no extraneous cations and in the presence of stable strontium or calcium ions.

2. The greatest adsorption of radiostrontium was shown by the clay minerals (montmorillonite, kaolinite, halloysite) micas, hydrous micas, peat, pyrolusite, phosphorite, and nepheline syenite. Therefore, when radiostrontium falls on soils, one expects highest contents where these minerals are present, other things being equal.

3. It was established that the ability of natural materials to adsorb radiostrontium strongly depends on a large exchange capacity. The presence of calcium, even as little as 100 mg/l, considerably reduces the adsorption of microquantities of strontium from solution.

4. Radiostrontium, filtering into groundwater, migrates easily and may enter man and animal organisms.

Received September 11, 1958

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ATER—SOLUBLE ACIDS OF SOLID FOSSIL FUELS

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iences, USSR

The separation and investigation of the emical nature of fulvic acids from solid ssil fuels is of interest in studying the nature d genesis, not only of these materials, but so of soil humus. The formation and compo- ion of coal and soil have common features, hough essential differences exist depending the different conditions under which the mic material is deposited. In solid fuels, processes of synthesis in the peat and nite stages are probably more distinct from ose of oxidative destruction in the carboni- ous stage.

We investigated the acids of the filtrate maining after precipitating humic acids from alkaline extract of solid fuels, after remov- the bitumens, which are usually mistaken fulvic acids. The fuels investigated in- uded peat from the "Borovoye" deposit, umen'Oblast', earthy lignite from the Alekhs- driya deposit, and weathered coal from the znetsk basin: two bituminous coal samples different weathering from the Prokop'yevsk posit, Maneikha mine, and a low-grade coal om the Bungur-Listvyansk deposit, Bungur nel. Also investigated were coal samples idized with 30% H_2O_2 at 60°C: unweathered ft coal from Baydayevsk mine, and the resi- after extracting the humic acids from athered coal from Bungur tunnel. Finally, soluble acids, obtained upon decomposing humic acids from earthy lignite with sodi- metal in liquid ammonia, were investigated.

The soluble acids were separated accord- to the method described by Drozdova (2). previously used this method (Fig. 1) to dy the water-soluble materials obtained on decomposing humic acids with metallic dium in liquid ammonia (5).

The filtrates were adsorbed on activated rbon and successively washed with aqueous etone, water, and aqueous alkali. The al- i fraction, containing the true acids of the rate, was passed through cation exchanger SBS in order to remove cations and convert the acids to the hydrogen form. The acid solutions were evaporated under vacuum, and the residues extracted with cold absolute ethanol. An insoluble residue, containing 13%-25% of the organic material, remained and was not investigated further. In order to fractionate the fulvic acids, the alcohol solution was carefully poured dropwise into an excess of dry sulfuric ether. A brown amorphous precipitate formed, but considerable fulvic acid remained in solution in the ether. The precipitated fulvic acid was repeatedly washed in ether and dried at room temperature in a stream of nitrogen. Such precautions were necessary because freshly precipitated fulvic acids are easily polymerized in the presence of oxygen and moisture, especially at higher temperatures.

The ether-soluble part of the acid is easily redissolved in alcohol, but does not precipitate upon pouring the alcoholic solution into an excess of ether. Upon evaporating the ether, a mixture of tar-like acids, with a sharp characteristic odor, remains.

Thus, the acids in filtrates from the solid fuels studied were separated into amorphous, alcohol-soluble, ether-insoluble acids (with every reason to consider them as fulvic acids) and tar-like acids soluble in both alcohol and ether. The latter constitute the major part of the separated acids in the filtrate (Table 1). A total yield of acids was not obtained because of considerable losses on the activated carbon and cation exchanger.

The acetone and water fractions desorbed from the activated carbon were not studied. The acetone fraction was present in significant amounts only in filtrates from peat and was absent in those from coal. Neutral material, desorbed with water, was present in small quantities in filtrates from peat and lignite; it was not found in those from weathered coal. Steam-volatile acids (traces of formic and up

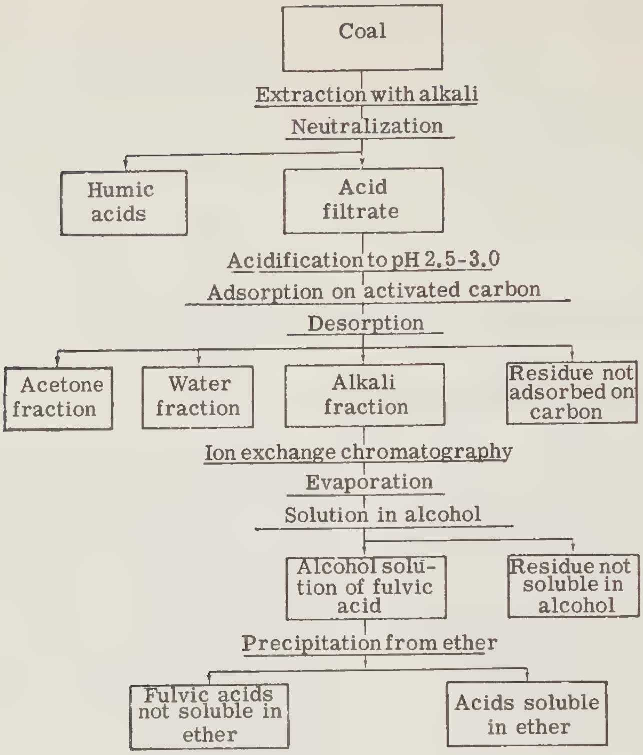
Coal
Extraction with alkali
Neutralization
Humic acids
Acid filtrate
Acidification to pH 2.5-3.0
Adsorption on activated carbon
Desorption
Acetone fraction
Water fraction
Alkali fraction
Residue not adsorbed on carbon
Ion exchange chromatography
Evaporation
Solution in alcohol
Alcohol solution of fulvic acid
Residue not soluble in alcohol
Precipitation from ether
Fulvic acids not soluble in ether
Acids soluble in ether

Fig. 1. - Diagram of the separation of fulvic acids from coal.

Table 1

Yield of fulvic acid and ether-soluble acids in percent of their total amount

Substance investigated	Fulvic acid	Ether-soluble acids
Peat, sample 1	22.28	77.82
Peat, sample 2	31.96	68.04
Earthy lignite	14.15	85.85
Weathered soft coal, samples at surface	8.50	91.50
Same, sample 3 meters from surface	—	100.00
Weathered coal, low-grade	10.27	89.73
Artificially oxidized unweathered soft coal	7.59	92.41
Artificially oxidized residue from low-grade coal	6.64	93.36

to 1.5% of acetic) were present in filtrates from the coals. Therefore, the acids from these coals may be separated without preliminary fractionation on activated carbon.

Thus, it was found that filtrates from peat contain, in addition to fulvic acids, acetone- and water-soluble materials of neutral character. Lignite filtrates contain fulvic acids, ether-soluble acids and water-soluble materials. Weathered coal filtrates contain fulvic acids, ether-soluble tar-like acids, and steam-volatile acids.

Fulvic Acids. The precipitated fulvic acid were an amorphous, light-colored product. They were soluble in alkalies, alcohol, concentrated acids, and molten phenol. They we

Table 2
Elemental composition of fulvic acids from peat and various coals

Substance investigated	Elemental composition in % of the organic material				C:H
	C	H	N	S+O	
Peat, sample 1	47.77	5.59	3.54	43.10	8.54
Peat, sample 2	49.09	5.48	3.79	41.64	8.95
Earthy lignite	42.34	5.36	4.56	47.74	7.80
Weathered soft coal	49.36	4.27	1.36	45.01	11.56
Weathered coal, low-grade	51.19	4.04	1.73	43.04	12.67
Artificially oxidized unweathered soft coal	49.58	4.58	2.17	43.67	10.82
Artificially oxidized residue from low-grade coal	42.31	5.53	1.24	50.92	7.65
Acids obtained by decomposing humic acids with metallic sodium	46.72	5.21	—	48.07	8.97

lightly soluble in cold and hot water, acetone, iore soluble in methyl ethyl ketone, and insoluble in benzene, dioxane, chloroform, ethyl ther, and carbon tetrachloride.

The elemental composition of the fulvic cids is given in Table 2. The carbon content s 42%-51%, hydrogen 4%-5.6%, and nitrogen .3%-4.5%. Thus, the composition of fulvic cid of diverse origins shows a certain contancy. The composition is nearly the same s that of soil fulvic acid, in which the carbon ontent is 43.2%-49.9%, hydrogen 3.3%-5.8% nd nitrogen 1.8%-5.7%, according to data of yurin, Ponomareva, and Kononova (4, 6, 7, 8). he elemental composition of fulvic acid from oal oxidized under natural conditions differs rom that of the other samples by a somewhat igher content of carbon and lower contents of itrogen and hydrogen. We believe this reects the oxidative destruction processes ocurring durint its formation.

The determination of active groups in fulvic cids by methods commonly used to study umic acids presents certain difficulties beause of their solubility in a number of solents. The total content of active acid groups as determined by reaction with barium hyroxide.

In addition, the equivalent acidity was dermined by titrating an alcoholic solution of lvic acid with 0.1 N sodium hydroxide. The gher value obtained in the latter case indicates e presence of easily hydrolyzed groups. The ntent of carboxyl groups was determined by action with calcium acetate, and also by ethylation with methyl alcohol. The content phenolic hydroxyls was determined by the fference between the total content and the content of carboxyl groups. For this purpose, the reaction with diazotized paranitroaniline was also used, since it can detect the presence of phenolic hydroxyls in the para position (1).

According to our data (Table 3), the total content of active acidic groups in fulvic acid, determined by chemisorption, was 8.5-9.8 meq/g, and that of carboxylic groups was 2.4 -4.7 meq/g. A smaller value for carboxyl groups was obtained by methylation than by reaction with calcium acetate. This may be explained by the presence of lactone groups, acting as acids in aqueous medium, or by the partial formation of complex esters upon solution in absolute ethanol.

The content of phenolic hydroxyls, determined by the reaction with diazotized para nitroaniline, are also somewhat lower than those determined by chemisorption.

The content of methoxyl and ethoxyl groups in fulvic acids, determined by the method of Fibeck and Brecher, was 1.7-2.9 meq/g. Characteristically, these groups, or rather those split out by hydriodic acid under the experimental conditions, are present in the fulvic acid from weathered coal, while such groups are absent in coal and in humic acids from weathered coal. This may be explained by the partial formation of complex ethyl esters of fulvic acids upon extraction with cold ethanol, even though dissolving salicylic acid in ethanol under the same conditions does not result in formation of complex esters.

The hypothesis of partial esterification, upon obtaining the acids from the filtrate in this way, has been confirmed as follows. Since the

Table 3

Content of functional groups and molecular weight of fulvic acids from various solid fuels

Substance investigated	Content of active groups, meq/g						Equivalent acidity	Cryoscopic molecular weight
	Metoxyl	Chemisorption method			Carboxyl by methylation	Phenolic by azo combin.		
		Total	Carboxyl	Phenolic				
Peat, sample 1	2.56	8.94	4.26	4.68	1.77	3.45	10.11	250
Peat, sample 2	2.93	8.58	3.28	5.30	1.79	2.83	11.67	284
Earthy lignite	2.58	—	—	—	—	—	—	—
Weathered soft coal	2.25	9.36	—	—	2.62	—	12.33	170; 168
Weathered low-grade coal	1.90	9.80	—	—	3.24	—	13.33	211
Acids obtained by decomposing humic acids with metallic sodium	1.67	8.52	2.42	6.10	2.43	5.68	11.16	132

acid filtrate from weathered coal gives no fractions desorbed from activated carbon with acetone or water, pure acids could be extracted from this material without preliminary sorption on activated carbon. Therefore, humic acids from the alkaline extract of soft coal were precipitated with acetic acid. The precipitate coagulated rapidly and was easily filtered. The filtrate, containing an excess of acetic acid, was twice passed through a cation exchanger, after which the water and acetic acid were evaporated under vacuum, and the acid was dried to constant weight. In the completely dry acids, the content of ethoxyl groups amounted to 0.98 meq/g, which was lower than shown in Tables 3 and 4 for acids from the same samples.

Acids separated by dialysis from the filtrate of Kol'sk podzol also had a low number of these groups, 0.40 meq/g.

Because fulvic acids and their derivatives are soluble in water, alcohol, and pyridine, some methods are not successful. These include acetylation, the determination of aldehyde groups using the dimedon reaction, and the determination of carbonyl using phenylhydrazine. Aldehyde groups were shown only qualitatively by the reduction of mercuric salts and Fehling's solution.

The molecular weights of the fulvic acids were determined cryoscopically using phenol, in which fulvic acid from weathered coal is soluble in water, the molecular weight was determined in both phenol and water, with good agreement in results.

We obtained average molecular weights for the fulvic acids ranging from 170 to 284. It was lower for fulvic acid from weathered coal than for that from peat. A still lower molecular weight was shown by the fulvic acid obtained by decomposing humic acids from earthy lignite with metallic sodium in liquid ammonia.

Thus, fulvic acids from coal and peat are amorphous, light-colored acids of low molecular weight, having an aromatic structure. The low C:H ratio indicates a polymethylene nucleus, together with aromatic structure or a relatively high content of aliphatic side chains. These acids contain, in addition to carboxyl groups, phenol hydroxyls, methoxyl, and carbonyl groups in various proportions.

Comparison of the oxygen content obtained in the elemental analysis with the sum of oxygens combined as acid and methoxyl groups indicates a considerable portion of oxygen in inert, non-exposed combinations. This may be carbonyl and quinone groups, the presence of which is shown by qualitative tests, as oxygen of the saponifyable groups indicated by the difference between determinations in alcoholic and aqueous alkali, or as the oxygen of heterocylic compounds and bridges. The presence of lactone groups is proposed.

The lack of correspondence between molecular weight and content of active groups, which determines the chemical equivalence of these acids, shows that we have a mixture of varying composition and that the determined molecular weight represents only an average value.

Ether-soluble Acids. This group of acids differed basically from fulvic acids in a number of characteristics. They were soluble in various organic solvents, such as acetone, dioxane, and low molecular weight alcohols.

Table 4

Elemental composition of ether-soluble acids separated from various solid fuels

Substance investigated	Elemental composition in % of the organic material				C:H
	C	H	N	S+O	
Peat, sample 1	50.19	6.21	1.86	41.74	8.08
Peat, sample 2	48.06	6.35	1.37	44.22	7.56
Earthy lignite	51.79	6.33	0.79	41.09	8.18
Weathered soft coal, sample at surface	54.06	5.64	0.82	39.48	9.58
Same, sample 3 meters from surface	53.25	5.88	0.58	40.29	9.05
Weathered low-grade coal	55.44	5.64	1.16	37.76	9.83
Artificially oxidized residue from coal	48.56	5.52	—	45.92	8.79
Artificially oxidized unweathered coal	52.04	6.08	0.90	40.98	8.56
Acids obtained by decomposing humic acids with metallic sodium	44.20	5.61	—	50.19	7.88

Table 5

Content of active groups in ether-soluble acids

Substance investigated	Content of active groups, meq/g					Cryscopic molecular weight
	Methoxyl	Chemisorption method			Carboxyl by methylation	
		Total	Carboxyl	Phenolic		
Peat, sample 1	4.96	7.46	2.75	4.71	0.93	153
Peat, sample 2	5.96	7.49	3.72	3.77	0.67	158
Earthy lignite	5.49	6.29	3.43	2.86	1.13	207
Weathered soft coal, sample at surface	6.09	7.79	3.75	4.04	0.76	214
Same, sample 3 m from surf.	6.81	7.46	3.84	3.62		
Weathered low-grade coal	6.80	7.62	3.69	3.93	1.85 0.49	105 132
Artificially oxidized residue from low-grade coal	5.24	—	3.77	—	—	118
Artificially oxidized unweathered soft coal	5.57	9.04	3.48	5.56	—	185
Acids obtained by decomposing humic acids with metallic sodium	4.47	7.58	4.23	3.35	1.47	181

hey were partially soluble in benzene and soluble in water and acids.

Compared with fulvic acids, the ether-solu-e acids contained more carbon and hydrogen d less oxygen and nitrogen (Table 4). Basic fferences in the elemental composition were t observed between samples of different or-in. The contents were 48.0%-55.4% carbon, .5%-6.3% hydrogen, and 0.58%-1.8% nitrogen. The C:H ratio for ether-soluble acids was lower than that for fulvic acids from the same source. The acids obtained from one artificially oxidized sample were an exception.

The ether-soluble acids had fewer oxygen containing groups than fulvic acid (Table 5). The contents of active acidic groups, determined by the chemisorption method, were: total, 6.29-9.04 meq/g; carboxyl, 2.75-4.23

meq/g; and phenolic hydroxyls, 2.85-5.56 meq/g. Methylation with methyl alcohol again gave low values compared with the chemisorption method. An appreciable content of methoxyl groups, 4.96-6.81 meq/g, even greater than in fulvic acid, indicated the formation of complex esters in alcohol or complex changes occurring in the synthesis or destruction of the organic material of coal.

The ether-soluble acids reacted with diazotized amines, reduced Fehling's solution, and gave positive indication of quinones with ammonia. The molecular weights of the ether-soluble acids were determined cryoscopically in dioxane. They were 105-214, lower than those of fulvic acids. The acid from lignite had the highest molecular weight. There is reason to believe that, in this case, partial formation of complex ethyl esters occurred upon extraction with absolute ethanol.

Establishment of the compaction and structure showed that two types of acids were separated from the acid filtrate after precipitation of the humic acids from solid fuels, and fractionation on activated carbon and cation exchanger. These were amorphous acids, related to fulvic acids, and tar-like acids, more soluble and with lower molecular weight. The acids were grouped into two types almost independent of origin. Both are aromatic acids, containing methoxyl, carboxyl, and phenolic hydroxyl groups. The lower molecular weight acids have a higher content of carbon and hydrogen and lower content of oxygen. The acids also vary in optical density of their alkaline solution. Figure 2 shows the optical density of 0.02% alkali solutions of different acids from peat, including humic and hymatomelanic acids separated by L. N. Yekaterinina. Humic acids have the highest optical density, followed by hymatomelanic and then fulvic acids. Similar results have already been shown for soil acids by Kononova (3). The ether-soluble acids show the lowest optical density. The same was found for acids separated from weathered coal, with still sharper differences between different types of acids. The lowering of optical density with decreasing molecular weight may be explained by a decreasing relative content of aromatics, which is accompanied by a decreased content of chromophoric groups (conjugated double bonds between carbons).

Both groups of acids are mutually interconvertible, since the ratio of acids is determined by the conditions of their precipitation from alcoholic solution. These acids may be formed, first, through synthetic processes from products of the bacterial decomposition of decaying plant residues, and second, through oxidation and hydrolysis of the neutral, high molecular weight material of coal humus.

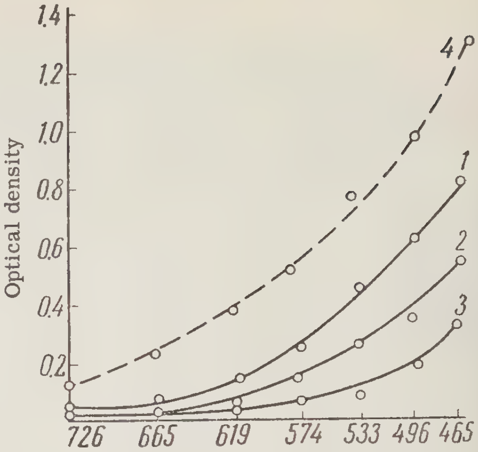

Fig. 2. - Optical density of alkaline solutions of acids extracted from peat.

1 - hymatomelanic acid; 2 - fulvic acid; 3 - ether-soluble acids; 4 - humic acids.

Conclusions

1. After precipitating humic acids, the filtrate acids from peat, earthy lignite, coal oxidized under natural and laboratory conditions, and those obtained by splitting humic acids with sodium metal in liquid ammonia were fractionated on activated carbon and cation exchanger. The separated acids were partially esterified with ethanol. They were characterized by composition, properties, and molecular weight.

2. After purification on carbon and cation exchanger, the acid filtrates were shown to contain two types of aromatic acids — amorphous fulvic acids and tar-like ether-soluble acids. The amount of the latter was considerably greater and depended on the conditions of separation. The two groups differed in molecular weight, optical density of their alkaline solutions, elemental composition, and content of active groups. The composition of acids within each group was very similar and depended little on the original material.

3. Soluble forms of humic acids are possibly formed through synthesis from products of the bacterial decomposition of various chemical compounds in the makeup of decaying vegetative residues, as well as through destruction of the humic acids and more complex neutral substances of coal humus. Transformation of acids from one form to another is accompanied by complex changes in composition, and is not simply a hydrolysis process.

4. The conclusions reached, and also the methods of separating and investigating the water-soluble acids, may be applied to studies

the formation and composition of soil humus.

Received May 28, 1959

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CLASSIFICATION OF FINE AND MEDIUM RELIEF SPACES

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In the geographical literature we encounter the concepts micro- and meso-relief, signifying fine and medium relief forms and their combinations, which are distinguished in the compilation of special maps (geomorphological, soil, geobotanical). In addition, increased use is made at the present time of the term nano-relief (minute relief), signifying even finer forms than micro-relief. Despite the wide use of these terms, there are still differences of opinion regarding the meaning of the terms and the principles for distinguishing and combining forms of different dimensions. This is a hindrance to mapping and frequently makes it impossible to compare results obtained by different investigators in different regions. In this paper we attempt, by induction from available information, to establish qualitative and quantitative characteristics for meso-, micro- and nano-relief, without regard for the larger forms (macro- and mega-relief) determining the structural outlines of large surfaces (mountains, tablelands, lowlands, plains, plateaus, wide valleys, etc.).

Fine and medium accumulative and destructive relief forms and their combinations are classified as morphosculptural forms (1). They are formed chiefly by the action of geographical factors. From this standpoint there are differences between fine and medium forms.

Geographical (exogenic) factors are predominant in the development of the fine forms, and their genesis is closely associated with the process of soil formation. Endogenic factors, mainly neotectonic, are of considerably significance in the development of the medium forms (meso-relief), sometimes equalling the geographic factors in importance.

A feature of the small forms is their youth, while meso-relief is usually the result of a longer geological development. Hence in addition to the forms developing under the influence of external physical conditions (relief of sands, frost action forms, etc.), there is a widespread meso-relief reflecting the influenc of other external physical conditions from the Quaternary and pre-Quaternary Era (early ice-age relief, Turtkul and low hill relief).

Hence the differences between fine and medi forms are not merely external but fairly profou depending, as observation shows, primarily on the nature and duration of the process of relief formation. This process is basically determin by the interaction of a number of simultaneousl operating factors. As the relief develops, the interaction becomes more complicated and involves new factors.

The relationships are simplest for the fine relief forms (nano-relief), which are governed by the action of one or more relatively briefly operating factors. Micro-relief is subject to t most complicated, multifarious, and prolonged development. For example, a sand ripple on any kind of flat surface or on the surface of a barchan is the result of simple retardation of t wind in the air layer near the ground (9) as the result of friction. Heaped sand micro-relief also requires the presence of a more or less substantial obstruction. Thus a new factor is involved and the development process becomes more complicated. Subsequently, with the formation of sandy meso-relief, the process is complicated further as a result of modification of the water regime and stabilization of the sur face by psammitic vegetation. There is a change in the effect on the wind in the air laye near the ground, which has been responsible f raising and modifying the sand relief in the fir place. Transition from forms of one size to forms of another is usually accompanied by a reconstruction of the relief and modification o its appearance. For example, a sand-heap micro-relief has a different morphology from the sand ripple and it differs sharply in appear ance from the barchan meso-relief. Erosion micro-forms — rills, waterways, and mounds — differ sharply in morphology from erosion meso-shapes, i.e., gullies, ravines, and idges. The micro-stages of a slip have a diferent appearance from a slip meso-relief and o on.

It is rare in nature that a large form (small epression, sag — see below) will develop rom a small form without a substantial change its appearance. An increase in size is sually accompanied by a modification of the ain morphological features.

Along with the small forms (representing the itial stages of development of some types of edium forms) which evolve, modify, recontruct fairly rapidly, other types of nano- and icro-relief are widespread. The latter, in e process of relief and development, pass apidly from the embryonic forms to a certain mit, and then remain for a long time without ndergoing basic modifications under specific onal and environmental conditions. These rms, as well as the soil, exist as it were in certain state of dynamic equilibrium with the nvironment and are indices of its special haracteristics. In fact, it is not an equilibrim, but a retarded development together with e environment. Here the structure of the reef and soil conforms to the nature and speed change of the general (zonal, provincial), and cal physiographic features. The suffusion icro-relief of the Caspian Plain is widely nown. Its formation from the nono-relief , 6, etc.) can now be considered as established his unusual type of fine relief develops on flat wlands made up of salinized marine clay loam vered with solonetz. Its salinized layer is npermeable and the thickness of the upper pereable layer is negligible. As a result of this, mospheric waters accumulate in every depresion, even the smallest ones, where slight seting phenomena are possible. The wide occurence of depressions in solonetz may be exlained by the different water characteristics of dividual genetic layers in these soils and the bility of the solonetz to sharply change its lume in the wet and dry state. As a result, ssures always form on the surface of solonetz hich promote more intense local seepage of ater, the leaching out of salts and the modifiation of the soil structure accompanied by the rmation of primary depressions. The influnce of seeping water on the solonetz itself is ry limited because of its low permeability. his creates different soil conditions under the mpact surface of the solonetz and under the ssured area. Once initiated, settling causes rther soil fissuring, increases the area subcted to the action of seeping water and ineases the area of the depression. The ineased surface moisture in the depression crees more favorable conditions for the growth of getation and the establishment of new forms, r the shading of the soil, for the protection of e soil from evaporation and the collection of ow. All this favors the progressive leaching the soil, the further development of the depression, the formation of a clearly-defined depression, and, in general, to the formation of a depression nano-relief. This stage of development of the depression is characterized by leached and solodized solonetz and solonetzic, slightly meadow-like chestnut soils (two member complex).

Subsequently, as the depression deepens, fissuring intensifies around its edges. Small burrowing animals (blind worms) enter the fissures and in loosening the soil make it more permeable to water. Such fissured sections of solonetz are more adaptable to grassy vegetation. Together with the burrowing animals, vegetation promotes the destruction of solonetz layers and the formation of a clearly-defined micro-relief depression with its specific biogeocoenosis and meadow-chestnut soils.

With the further development of the depression (fissures, sags), fringe or tongues of leached solonetz together with slightly meadow-like chestnut soils form at its periphery. As the sags deepen, the depressions increase. In the soil of the fringes, meadow phenomena intensify and the edge of slightly meadow-like chestnut soils widens. The two-member complex changes into a three-member complex. The more the complex is developed the greater the proportion of slightly meadow-like chestnut soils becomes.

In the initial stages of development, the growth of the depressions led to an increase of their water catch and an intensification of settlement processes. The further development of the depressions, causing the redistribution of surface runoff over a larger number of bigger depressions, reduces the moisture in each. This begins to limit the growth of the depressions. Conditions are not favorable for the development of suffusion meso-relief from the suffusion micro-relief. As an exception, adjacent depressions may combine to form beaded systems or a general meso-relief depression. As a rule, the genesis of the depression meso-relief is different.

There are descriptions of two-member complexes on the same Caspian Plain (6) which do not possess a micro-relief during the development of the nano-relief — (the sag is 3 cm deep). They are represented by solonetz with goosefoot, black wormwood and solonetzic meadow-chestnut soils under white wormwood, fescue grass and Agnus castus. The absence of a depression micro-relief larger than the nano-relief in these complexes is explained by the coarse texture, or the stratification of soil-forming material. In the first stages of development, grassy patches of gramineous plants with a mixture of seablite and black wormwood are scattered over the goosefoot cover. In the subsequent stage of development two types of patches occur, small circular patches under pyrethrum, corn, and sedge, and larger patches under pyrethrum, sedge, corn and white wormwood. The soil in the small patches is desalizined solonetz. Soil in the large patches is a solonetzic meadow-chestnut. The desolonetzation of solonetz proceeds under the action of vegetation. Such complexes are not limited in their development. Nano complexes occur in the first stages, followed by micro complexes, changing into combinations where meadow-chestnut soils reach large dimensions.

The primary phases — elements of nano-relief, or "micro-micro-relief," have been described by Kachinskiy and Dolgopolova (7, 3) in podzolic soils and chernozem. These authors established differences in the soils of small depressions and ridges, a few centimeters in size. These differences were detected from variations in the physical, chemical and physical-chemical properties of the soils. A regular alternation of these forms from one relief feature to another was also established. However, a further development of this "micro-micro-relief" (nano-relief) into micro-relief does not occur under these conditions.

The transition of nano-relief to micro-relief is not always readily detected, and their connection can only be disclosed by sufficiently thorough and complete investigations. Thus a hilly meso-relief is widely developed on the terraces and slopes of watersheds in Central Siberia, which consist of a fairly thick layer of clay loam. The mounds are roughly 20 m in diameter and the depressions up to 10 m. The relative heights are 1.5-3.0 m. Vegetation is varied, consisting of feather-grass steppes with various grasses, and grassy, birch or pine woods. In conformity with the differences in vegetation the soil consists of fertile, leached chernozem with a moderate amount of humus, on the ridges and meadow-chernozem and bog soils in the depressions. This relief is of ancient thermokarst origin, complicated by suffusion. On the surface of these mounds, in the more frost-susceptible areas, contemporary frost fissures and regular polygonal nano-structures occur. Animal and vegetable life plays an active part in these. Ants occupying the central sections of the nano-polygons and building ant-hills, accentuate the differences in the elements of the nano-relief. Moisture-loving vegetation occupying the fissures, on the other hand, frequently promotes their deepening. In this case, the micro-relief is not a contemporary formation, while the nano-relief is associated with the micro-relief only as a factor of contemporary relief formation.

The genesis of the forms and types of relief varies greatly, which, similar to those characterized previously, exist over a long period under certain conditions of the environmental medium and develop with it. In some cases relief is closely association with the deposits on which it forms, very much like soil. It is known that the foregoing characterized suffusion depression micro-relief of the Caspian region develops only where a flat undrained surface consists of salinized marine clay loam (2). The micro-creep slope relief forms where, oth conditions being equal, the substratum is claye Many solifluctional relief forms in the tundra and outside of it are not less closely associate with the substratum.

As the foregoing shows we encounter in nature, on the one hand, types of small relief which fairly rapidly modify, reform, and pass through a series of development stages without visible changes in the environment, to form finally definite types of meso-morphosculpture (such as erosional, sandy, karst and many othe genetic types of relief). On the other hand, there are other types of small relief so closely associated with definite physiographic conditions, that their further intense development requires changes in the prevailing conditions a a result of a change in the climate, base erosio coast lines, flood-plain regime of rivers, surface runoff conditions, drainage of the site, an so on. In addition, an important factor is the gradual development of the micro-relief itself, which leads to mutual modifications of the soil and vegetation, runoff, the redistribution of atmospheric precipitation, and the regime of soil ground water, and which, in the final analysis, in turn modifies the actual conditions of its own development. The process of evolution of the relief without changes in physiograp conditions is widely distributed in the various zones of the country. It can be observed in the Caspian semi-desert (see above), as well as in taiga regions, and in the tundra zone. For example, in wet depressions between hills in the Yamal Peninsula frost heaving phenomena occu which are accompanied by the formation of mounds. At the base of the mounds there are breaks in the soil in the form of black gaping fissures, not covered by moss. Further, as the result of the thawing of the frozen ground along the cracks and settling of the surface, fine depressions form (nano-relief). The dark coloring of the surface favors further thawing and settling of the soil. As a result the fissur depressions near the mounds become longer an merge with each other to form larger, elongat micro-relief depressions. Sod forms on their surface, consisting of grass, sedge or a loose cover of grass-sedge, sometimes with cotton grass. The further development of these depressions leads to the formation of shallow an relatively straight furrows, here called runoff channels. These have a relative depth of approximately 20 cm, a width of 5-8 m, are discontinuous, and have an overall length of from 10-15 to some tens and even hundreds of mete Sedge-cotton grass bogs form in the runoff cha nels in which a relatively thick peat bed (up to

0 cm) develop rapidly. The peat insulates the rozen ground and stops thermokarst processes, .e., the further development of runoff channels. In this type of landscape there is a clearly-defined genetic relation between the forms of he nano- and meso-relief. However, the meso-relief forms are small and their development stops at the intermediate stages. Large runoff channels occurring in the northern regions of the Yamal Peninsula develop similarly, but in larger frost fissures, associated vith polygonal processes.

The foregoing shows that during the development of the small relief, stages can be distinguished where the modifications reach a certain limit. Then either new characteristic conditions for relief formation develop, and a nore active and visible reconstruction begins, or the process slows down, until the new actors are introduced. This principle is well-expressed not only in the development of small, but also medium, relief, the existence of which is of longer duration than that of small orms.

Another general principle emerges. The ntensity of the reconstruction of small relief during its evolution, that is, the speed with which it passes through the individual stages and changes into meso-morphosculpture (and ater the development and reconstruction of the meso-relief), depends on the degree of conformity or noncomformity of the relief to the conditions of its formation and primarily to the nature and intensity of the principal factor, or set of main factors, of relief formation. Thus n the development of the relief of our sandy deserts, the initial stages (sandy nano- and micro-relief) are usually overcome very quickly. The wind regime of these regions, the lat surface, the loose substratum, the small amount of precipitation and, in the early stages, vegetation which is incapable of retaining the oil, are unfavorable for preserving any type of mall forms for a long time. The small relief ere does not conform to concrete conditions of and transport. Subsequently, the gradual complication of the process, as a result of new actors entering into play (modification of the water regime, the establishment of vegetation, ew outlines and the dimension of sand forms, tc.), leads to the formation of sandy meso-morphosculptures, remaining for a long period n a certain state of conformity with the conditions of their existence. They undergo only low and gradual modifications until the time when latter, or external influences, introduce ew inconformities and initiate a new reconstruction of the relief.

The same principle is also seen in the more omplex process of the evolution of the erosional relief where the main relief-forming actors under any geographical conditions are owing water (surface runoff) in interaction with slopes and recent tectonics. During the erosion of the surface and the formation of forms of linear erosion, the alternation of the stages of development of small relief forms (furrows, gullies, washed-out hollows, micro-ridges, etc.) and the evolution of meso-forms (ravines, ridges, valleys) is fast, if there is enough surface water and slopes promote rapid runoff. On the other hand, the persistence of small erosional forms, negative or positive (erosional mounds, microwatersheds), is promoted if the amount of surface water is small and the slopes are gentle. Conditions in such areas are not conducive to fast runoff, but to the slow spreading of water over a flat surface. The water stagnates in depressions and quickly evaporates under arid conditions. Similar conditions are encountered on the flat lowlands of the Caspian Plain in clay loam valleys fringing the western slopes of the Kopet-Dag in southwestern Turkmenistan, on the Ustyurt, and in many other regions.

These simple relationships under various zonal and local conditions are complicated both as the result of variations in the significance of the main factors (variation in the volume of runoff, movements of earth crust), and as the result of new important factors entering into play in the process, such as the nature of the substratum being eroded, the degree of development of sod and intensity of plant growth, slope exposure, plowing, cutting of forest, etc. In connection with this, embryonic erosional forms persist over a long period of time in certain regions in spite of sufficient precipitation amounts and appropriate surface slopes. For example, in a number of regions of the Upper Volga and the Obshchiy Syrt, steep, southern slopes, consisting of loose carbonate rocks, are covered by a system of fine, short parallel or radial furrows, forming characteristic "micro-folds" on slopes, which are governed by the lithology and rapid early runoff (when the ground is still frozen). Further east, in the Orenburg Steppes, north of the Ural River, small erosional forms, predominantly of the ridge type (micro-ridges and hollows with sod-covered slopes), are more widespread on slopes of varying steepness than erosional meso-forms (ravines and ridges). This is conditioned by the existence at shallow depth of dense carbonate sedimentary rocks, preventing deep erosion. In places in the same regions the inhibiting role is played by vegetation, which rapidly spreads in well-watered erosional depressions.

The horizon of secondary carbonates has a retarding effect in the development of eolian processes on sandy soils.

When vegetation is destroyed, which retains the soil, only the upper soil layer is blown away. The underlying carbonate layer favors the initiation of a new cycle of sand retention by vegetation.

Examples of another type are found in the eastern regions of the Turgay plateau, located in the dry steppe and semi-desert. Here, where the amount of precipitation is small and the surface is generally flat, the erosional dissection of slopes is strong and linear erosional forms develop rapidly. This is related to the recent uplift of the region and the continuous, although slow, growth of slopes and height differences, which constantly increase runoff and erosion.

Let us now characterize the quantitative and qualitative features of small and medium relief forms (nono-, micro- and meso-relief). When characterizing the dimensions of the various forms, the certain arbitrariness of quantitative characteristics should be kept in mind. This is particularly true when dealing with forms of similar dimensions, particularly nano- and micro-relief forms.

In generalizing the material relating to the quantitative characteristics of relief forms, we arrive at the conclusion that it is necessary to take into consideration simultaneously two indices: diameter and difference in heights of positive and negative relief forms (that is to say the height or depth of the form).

The nano-relief or dwarf relief represents small irregularities of the surface, with a not always clearly-defined alternation of raised and depressed elements. The nano-relief forms in the first place as the result of processes of soil formation and association suffusion-karst, thermokarst, micro-creep, and frost action processes. In the development of the nano-relief, in the case of gentle slopes, a considerable role is played by processes of seasonal linear erosion, processes of mass movement along slopes (particularly during seasonal thawing of the ground), wind action, and the activity of rodents and burrowing animals. A characteristic feature of nano-relief is that it does not itself govern the micro runoff. An important role in its development is played by vegetation which governs snow retention, seepage or evaporation of meltwater in the soil and, in connection with this, the initiation of suffusion, micro-creep, heaving and other processes. A characteristic feature of nano-relief is usually its instability, and mobility of forms. Readily forming, they can easily be changed or destroyed. In addition, nano-relief more than other categories reacts to the local characteristics of relief-forming conditions (exposure of slopes, lithology, micro-climatic variations, etc.). This explains why, being closely associated with zonal conditions (types of nano-relief of the southern arid regions, tundra, etc.), the nano-relief has at the same time a wide diversity of forms even within the limits of a small physiographic region. The greatest role is played here by th nature of the substratum (lithology of surface deposits, soils).

In arid regions, the nano-relief may be exemplified by small depressions (as the embryo ic stage of formation of a depression micro-relief), small hillocks — marmot mound, anthills, polygonal fissured surfaces in flood plains and "gaps" in regions of carbonate chernozem and chestnut soils, seasonal erosional furrows, micro-erosional hillocks on slopes, sand ripples, sea-coast sand hills and "tresses" and many others.

In tundra and taiga regions the types of nano-relief forms are represented by small stone medallions, a heaving-mound relief, small creep steps on slopes, marsh hillocks, wind-swept depressions, wooded hillocks, etc

The diameter of nano-relief forms usually varies from a few centimeters to 0.5-1.0 m, reaching 2-3 m only in rare cases. Relative heights vary from 1-3 up to 30 cm, rarely up 50 cm. Where the indices take on maximum values (D = 300 cm, H = 50 cm), the forms shou be assigned to the micro-relief category.

Micro-relief is a combination of small positive and negative relief forms, differing from nano-relief by their larger dimensions, lesser changeability, and regular combination and alternation at the site. Micro-relief is frequently a later stage of relief development tha the nano-relief (depressed micro- and nano-relief). However, since the nano-relief stage is rapidly overcome, one actually gets the impression that micro-relief forms develop without passing through this stage. This is frequently observed in the development of erosio al and eolian micro-relief. In individual case micro-relief actually forms without passing through the nano-relief stage. This depends primarily on the intensity of the process and the concrete conditions of relief formation. F example, such forms as heaving mounds, cree micro-relief, alluvial cone micro-relief, and a number of flood-plain micro-relief forms m have such dimensions in the first stages of formation, depending on the intensity and natu of the generating process, that they cannot be classified as nano-relief.

The outward appearance of micro-relief, a well as of nano-relief, is zonal and depends o the local characteristics of physiographic conditions, the substratum on which it develops, etc. However, being generally a later stage development, having a more complex system relationships with the ambient medium and larger dimensions than nano-relief, micro-relief is usually more resistant to local variations in physiographic conditions. It is more subject, so to speak, to the tendency of evelopment of its specific genetic type and rects less to episodic and seasonal influences.

The origin of micro-relief forms and types aries. It may originate as a result of sufsion-karst, suffusion-erosional, frost, creep, olian, biological (the activity of burrowing nimals, molehills, etc.)and other processes, sually taking place against the background of e predominant process of soil formation in a ven region. In turn being an important ctor in the redistribution of atmospheric prepitation on the earth's surface, particularly arid valley regions, micro-relief, to a reater extent than nano-relief, has an influnce on the hydrological regime of the soil and etermines many local characteristics of salt igration during the process of soil formation.

Micro-relief in arid regions is exemplified y: suffusion-karst depression, biogenic hillck (grouped molehills, individual and groups marmot mounds, etc.), erosional and ffusion-erosional (erosion furrows, etc.), olian sand-heap (Urpak-Kum), etc.

Tundra and taiga regions are characterized peat-mound micro-reliefs, frost mounds, one polygons, micro-creep relief on slopes, ost fissures, runoff channels, arctic tundra olygons, cryogenic low hills, cemetary ounds, etc.

Micro-relief forms have a diameter of everal meters, varying from 1-10 m, and ly rarely exceeding this value to reach up to m. The height of micro-relief forms is nall, usually varying from 10-15 cm, and ery rarely reaching 1.5-2 m. When a microelief form reaches maximum dimensions, oth in height and diameter, it should be assified as meso-relief.

Meso-relief includes forms larger than icro-relief and their combinations, usually nding a specific geomorphological character the appearance of the site. Meso-relief delops without being necessarily influenced by e soil formation process, although this freently occurs (for example, the formation of olonchak and the subsidence of solonchak deessions as salt is blown away). In the ajority of cases, the meso-relief itself exerts influence on the soil formation process, on e nature of soil distribution and vegetation aracteristics. Meso-relief has a great inuence on the hydrological regime of the area d the regime and mineral composition of ound water.

Meso-relief forms include ravines, ridges, nall, gently sloping hills, shallows, sinks and goons, eskers, kames and moraine hills, lleys of small rivers, lake basins, river and nudation terraces, various solifluctional rms, hydrolaccoliths, large runoff channels along frost fissures, tundra and arctic polygonal complexes, polygonal bogs and many more. Regular combinations of meso-relief forms, having a common history of development, create meso-relief types.

The primary role in the development of the meso-relief is played by factors on a geological scale, both exogenous and endogenous. The origin of meso-relief is varied. Its formation is affected by a complex of zonal and local physiographic conditions, geological conditions (structure, lithology, movement of the earth's crust), and paleogeographic factors (ancient glaciation, etc.). The reconstruction of meso-relief occurs when conditions of relief formation are greatly disturbed during the development of the process or during general changes in the environment: movement of the earth's crust, climatic changes, the artificial disturbance of surface runoff, changes in the erosion base, the meandering of rivers, etc. Meso-relief types usually reflect the zonal (latitudinal zones of valleys and vertical belts in mountains) characteristics of physiographic conditions. The most striking examples of this are the eolian sand relief of deserts and semi-deserts, the complex of frost-action phenomena (hydrolaccoliths, naleds, etc.) in the tundra and frozen ground taiga zones, the complex of periglacial phenomena at the margin of contemporary glaciers in the mountains, etc. The formation of meso-relief is no less closely related to the structure and tectonic regime of an area. Tectonics, when interacting with external factors, not only complicates the zonal aspect of meso-relief, but in a number of cases plays a leading part in the process of its formation, which, of course, does not exclude the fact that in the appearance of the relief there are always zonal (and provincial) characteristics. A good example of this is the lake-sediment relief of the northern section of the Caspian lowland (4), conditioned by salt dome tectonics, which consists of a series of alternating small salt dome swells — mounds and land-locked depressions, filled with debris and solonchak and having a specific arid appearance.

The meso-relief differs considerably from the micro-relief in dimension. The diameter of extent of meso-relief forms varies over wide range, from a few meters to 5 km, and in erosional and denudation forms (river valleys, denudation terraces, etc.) the extent of the forms may reach tens of kilometers (10-20 km). The depth or height of meso-relief forms vary from 0.5-10 m, sometimes reaching 50-60 m (conical hills of undulating plains, lumpy hillocks, ridges). It should be remembered that, as in the previous example, meso-relief forms are those with dimensions varying within the range of average or minimum values (e.g., d=0.5 km, h = 0.5 m; d = up to 3-5 km and h = up to 10 m, etc.), or where one of the indices reaches a maximum value and the other falls within the range of the means (for example d = 15-20 km, h = up to 10 m). If both indices have a maximum value (e.g., d = 10-20 km, h = 50-60 m), the relief form must be classified as macro-relief. An exception are cases where the given form, despite its large dimensions, occupies a clearly secondary position in relation to an analogous but larger unit or system (e.g., a single hillock in a system of gently rising hills in an undulating plain, etc.).

Conclusions

1. The classification of sculptural forms into two groups — small and medium — is based not only on their dimensions but on the nature of the process of relief formation, its complication in the development process and the different duration of the process.

2. Nano-, micro- and meso-forms of relief types having one and the same genesis can be considered as different stages of the process of development of a given type of morphosculpture. The decay of individual stages, the acceleration or retardation of development may be due to local characteristics of relief formation conditions and the greater or lesser intensity of the action of the main factor (or factors) of relief formation.

3. Together with the small forms, representing the early stages of development of the large relief forms, other types of small relief are also widespread. These, passing fairly quickly through part of their development, persist for a long time without much change at a certain stage under certain physiographic conditions, and develop with them. They are, to a certain degree, leading zonal, environmental, etc. forms.

4. The persistence of certain types of small and medium forms without great variations does not represent arrested development, but is the result of the conformity of the given forms and types to the conditions of their existence. Intense relief development and reconstruction are usually the result of a disturbance of this conformity.

5. The concrete classification of relief forms according to size involves a certain arbitrary approach to the quantitative limits in passing from one size category to another. This arbitrary approach results from the very nature of things and is not in conflict with the necessity for standardizing the main indices for obtaining comparable material for mapping (6).

Received April 17, 1959

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TEN YEARS OF RESEARCH IN SOIL CHEMISTRY AND AGRICULTURAL CHEMISTRY IN CHINA

Li Chen-Kvey

Before the Chinese People's Republic was founded soil science had not developed in the country as it should have. Only the geological research institute had a section on soil science which compiled a small-scale soil map of the entire country and made some regional soil studies. In the field of agriculture the soil science and fertilizer section carried out some experiments involving nitrogen, phosphorus, potassium, and other fertilizers. There were no more than 100 soil scientists throughout the country. Only an insignificant amount of work was done to determine the chemical and mineralogical composition of the main groups of soils. In agricultural chemistry research was confined mostly to elucidating the effect of N, P, and K on some crops in individual soil regions.

The founding of the Chinese People's Republic was followed by the organization of a network of soil science and agricultural chemistry institutes. Extensive investigations were carried out on nutrient elements, clay minerals, organic matter, micro-elements, and the physicochemistry of soils. A start has been made on the application of chemical, biochemical, and physical methods of research. Soil scientists and agricultural chemists have furnished the necessary scientific basis for work on the genesis and classification of soils, development of new lands, soil improvement, use of fertilizer and expansion of the national fertilizer industry.

We present below a brief survey of the results of research performed in these fields during the past ten years.

Mineralogical Composition of the Main Soil Group. Syun I (23) was the first to investigate the clay minerals of the main soil groups of China. He showed that the principal clay minerals are illite in the gray-brown, sierozem, gray cinnamon-brown, and yellow cinnamon-brown soils, kaolinite in red earths, and gibbsite and hematite in laterites. Syun I and Syuy Tszi-tsyuan' later found (24) that illite predominates in loesses and that some of it turns into montmorillonite, forming a transitional mineral; kaolinite appears with it. They assumed that loess deposits formed in glaciers or under other conditions and were then redeposited by eolation and other ways in dry climatic conditions. The loesses subsequently underwent partial decomposition, but this did not modify the original composition of the clay minerals.

A more detailed study of the mineralogical composition of Chinese red earths was made by Li Chen-kvey and Chzhan Syao-nyan' (12, 32) who showed that kaolinite, quartz, and montmorillonite are the predominant clay minerals in the soils of the subtropical region of Central China (Khunan', Tszyansi, etc. provinces). Kaolinite and halloysite predominate in the red earths of the tropical region (Guandun, Guansi, and Yun'nan' provinces). Lateritic clays in the Chinese tropics developed on basic rocks consist chiefly of kaolinite, gibbsite, and hematite. The mineralogical composition of the widespread yellow earths of Southern China at elevations above 800-900 feet is more complex. Kaolinite, montmorillonite, quartz, and illite predominate with some vermiculite present.

Research on the mineralogical composition of the red earths has revealed that calcium minerals are weathered first followed by sodium, magnesium, and potassium minerals. This explains the comparatively large amount of total natural and exchangeable potassium in strongly acid red earths. It is also the reason for the ineffectiveness of potassium fertilizers when added to grain crops.

During the past ten years Chinese soil scientists have made available extensive materials on the chemistry of the main groups of saline soils. Len Fu-tyan' and Syuy Shu-khua (17, 22) think that NaCl predominates among the salts of the maritime solonchaks in the coastal regions of Eastern China. NaCl constitutes on the average about 80% of the total soluble salts and about 15% of the sulfates. The same authors have described the salt tolerance of the main cultivated and native plants.

According to Chen' En'-fan (42), Chen' Bay-yun' (35), and Yan Go-shun (49), sodium sulfate and sodium chloride predominate in the saline soils of Northwestern China and Inner Mongolia. Solonchak soils are very common in these regions. Exchangeable sodium in the solonchaks constitutes 50%-80% of the exchange capacity.

An investigation of saline soils and groundwater of the Great Plain of Northern China made by a team of the Academy of Sciences, Chinese People's Republic headed by Shun I and Si Chen-fan (51) revealed that the solonchak soils of the Northern China flood plain are characterized by a sodium sulfate and sodium chloride type of salinization. They have also worked out methods for irrigating these soils.

Chemical Properties of Rice Soils. Yuy Tyan'-zhen' (44) and others have studied in the field the oxidation-reduction of rice soils. They believe that with a high OR potential the basic system should be "oxygen," but "organic matter" with a low OR potential; under normal conditions "iron" is not a factor that stimulates the OR processes. They have further shown that the vegetation may have some effect on the OR potential (45). For example, the OR potential rises when rice is planted, but falls when wheat is planted.

Several properties of the soil influence the oxidation-reduction regime. Van Dun-men and others (2, 3) stress the fact that irrigation substantially increases the amount of ammonia nitrogen in the soil, whereas nitrate nitrogen disappears within three days. The amount of ammonia nitrogen gradually decreases after it escapes into the tube of the rice. It has been demonstrated (15) that a certain amount of ammonia nitrogen also forms in nonirrigated rice soils and decreases with depth.

A change in OR potential in rice soils always causes a change in the condition of iron and manganese. Tin Chan-bu and Yuy Tyan'-zhen proved (25, 44) that manganese is more easily reduced than iron. After neutral soils are irrigated, more than 70% of the acid-soluble manganese is converted into low-valence forms. As a result of leaching of soluble low-valence forms of iron and manganese, the soil profile begins to become differentiated; a gleyed horizon forms with very low adsorption capacity. The content of bivalent manganese varies with the acidity of the soil. The relation between quantity of exchangeable manganese and hydrogen ion concention is another problem that has been examined (46).

The effect of highly pronounced reducing conditions in the soil on the sprouting of rice was studied chiefly to determine the toxicity of ferrous oxide and the sulfides. Khe Sin-fen (29) thinks that the low yield of rice fields is directly attributable to the presence of rusty water and sulfides. An investigation of the strongly acid saline soils in the coastal region of Guandun province shows (5) that the presen of a large quantity of sulfides and bivalent iro strongly acidifies the subsoil (pH=3) and there by influences sprouting. Yuy Tyan'-zhen and others (47) think that the depressed condition of rice with intensive reducing conditions is caused by an excess of reduced substances, primarily bivalent iron. However, under certain circumstances, especially on fields with large amounts of organic fertilizers, the content of bivalent iron may reach 0.3%, but the rice remains normal. Thus, the reason why intensive reducing conditions affect the sprouting of rice has not been determined.

The intensive migration of bases is quite pronounced in rice soils: the pH value and content of exchangeable calcium and magnesiu in the upper soil horizons are always less tha in the lower horizons (48). The relationship between acidity and OR potential depends on th soil group and methods of cultivation and fertilization used.

Research on Adsorption Capacity of Soils. Major attention has been focused on the nature of acidity as an important factor in the improv ment of strongly acid soils, application of phosphorous fertilizers, and liming. There are various views on the subject. Lin Yun'-syao and Yuy Tyan'-zhen (16) pointed out that exchangeable acidity in the acid soils of China is caused mainly by aluminum. They proved that hydrogen adsorbed in the soil is quickly replaced by aluminum. When the pH is over 5.5, the content of exchangeable aluminum is sharply reduced; when the humus content is increased, the amount of exchangeable hydrogen grows.

Some work has been done on the fixation of phosphorus by acid soils. Lu Zhu-kun' and U Mey-lin (27) have observed that the red earths of Southern China posses considerable capacit for fixing phosphorus. Soluble phosphorus in these soils is bound by available iron and aluminum, the degree of fixation increasing as the soil temperature rises. Acidity and composition of exchangeable cations strongly influence this process. Sun Shi (21) has shown that the greatest fixation of phosphorus takes place in soils saturated with Ca, the least in soils saturated with sodium and potassium. Phosphorus bound with Ca is extracted by 0.00 n of sulfuric acid (21).

Chen' Tszyan-fan studied the adsorption of nitrogen (36). He has classified the adsorption of ammonia by soils into "easily desorbe d "nondesorbed." With the former ammon- m may combine with available iron and alu- inum, forming compounds of the $R(OH)_2ONH_4$ pe which are desorbed during steam distilla- on; with the latter it becomes exchangeable nmonium released only in an alkaline solu- on.

U Tszhi-khua and Gao Tszyan-fan (28) sub- cted the chernozems of Northeastern China alternate wetting and drying and discovered at the amount of potassium changing into a olution increases substantially in the process. ne chernozems of Northeastern China have fairly high natural supply of potassium. It s been learned that part of the nonexchange- ole potassium is converted into the exchange- ole state under crops in loessial-like soils st as in the chernozems.

Organic matter. Research on organic matter s started just a few years ago. The main fort has been directed at investigating the oup composition of humus substances. Ven' i-syao, Chzyan Gosyan, and others (6) udied the composition of humus in character- tic profiles of chernozem, chestnut, brown, g, red earths, and yellow earths. They und that the composition of humus in the ernozem and calcareous soils of Northern ina corresponds in general to the geographic ttern of humus formation worked out by I. V. urin. In the strongly acid red earths and llow earths of Southern China the content of mic acids is low and their molecular struc- re is comparatively less complex. The fulvic id content of the upper horizons is high (the oportion of C humic acids to C fulvic acids the upper horizons is usually 0.1-<0.5).

S. V. Zonn and Li Chen-kvey (9) elucidated e effect of vegetation on soil formation, stress- g that the proportion of humic acids to fulvic ids is linked not only to the major forma- n like forests, savannas, etc., but also to e differences in composition of the plants in ch of these formations.

To study the cycle of matter and energy der tropical conditions, the Academy of iences, Chinese People's Republic set up iogeocenotic station, the first of its kind in e province of Yun'nan' with the cooperation of N. Sukachev and active participation of S. V. nn and N. V. Dylis. Among other projects, s station has begun systematic observations the accumulation, decomposition, and trans- rmation of organic matter in the soil under rious types of crops.

Analysis Methods. In the area of methods determining organic matter in the soil, Chen' zyan-fan and others have shown (37) that ating the soil with $K_2Cr_2O_7$ and sulfuric acid y substantially accelerate the decomposition organic forms of nitrogen without production of nitrate nitrogen or volatilization of nitrogen. Van Tszun'-chen proposed the methods of water distillation to determine the CO_2 escaping from organic matter. This involves the absorption of barium solution ($Ba(OH)_2$ x $8H_2O$) in the form of H_2CO_3, which is then determined by titration. The method shortens the time of CO_2 determination considerably and it can be used to find the percentage of carbonates (4). Great difficulties in determining the nitrates in organic fertilizers by colorimetry result from obtaining colored extracts. Chen' Shan-din (38) suggested using $FeCl_2$ to convert NO_3 into NO. The latter is absorbed by H_2SO_4 and H_2O_2 and during oxidation is changed back into NO_3, which yields satisfactory results in making determinations colorimetrically with the help of disulfophenolic acid.

To determine calcium and magnesium extracted from plants and soil, Chzhu Shao-lyan' (33) recommended the addition of citric acid to KCN extracts to form complexes of iron, aluminum, and manganese ions. The calcium and magnesium may precipitate directly without removal of the iron, aluminum, and manganese. Shi Tszi-tsyuan' and others (31) proposed semimicroquantitative analysis as a method for determining the exchange capacity of soils. They use normal solutions of $MnCl_2 - Mn(Ac)_2$ as a displacer of exchange bases and determine the excess of manganese by colorimetry.

To determine potassium, Chzu Shao-lyan' (34) suggested the use of sodium nitrate in the presence of which ammonium is oxidized while the escaping free nitrogen volatilizes.

Soil Fertility. During the ten years that the Chinese People's Republic has been in existence the agricultural research institutes have set up in 17 provinces more than 100 experimental stations to work on fertilizers. In 1957 the Institute of Soil Science and Fertilizers of the Academy of Agricultural Sciences carried out experiments with fertilizers at 150 experimental points in the main soil provinces of the country (31). On the basis of these experiments and a summary of analytical materials, the Institute of Soil Science of the Academy of Sciences, Chinese People's Republic has shown that a deficiency of nitrogen and phosphorus in Chinese soils is a common phenomenon while potassium, with the exception of a few districts, is generally more abundant. The Ministry of Agriculture and Academy of Sciences used these materials for compilation of a map and table characterizing the general level of soil fertility in the various districts and their fertilizer requirements for increasing the crop yield (10, 7).

Experiments to determine the effectiveness of phosphorus and nitrogen fertilizers performed on red earths over a period of many years have shown that the former are more effective. After the soil is gradually placed under cultivation, the amounts of phosphorous fertilizer and lime must be decreased from year to year (13).

Comparative Investigation of the Effectiveness of Nitrogen Fertilizers. Almost all the experiments involving the use of nitrogen in rice soils show that ammonia compounds are invariably more effective than nitrate compounds. The Agricultural Research Institute of Eastern China has gathered much material on the problem (51) that seems to indicate that soil colloids possess a greater capacity to adsorb ammonia nitrogen than nitrate nitrogen. Consequently, there is no leaching of nitrogen in rice soils. Some of the investigations show that the application to rice soils of nitrogen in the form of ammonium sulfate substantially increases its effectiveness (2). The reason is that under field conditions nitrate nitrogen is assimilated by rice much more slowly than ammonia nitrogen. This shows up very clearly when the rice is sprouting.

Field and greenhouse experiments have long since revealed that the conditions use of ammonium sulfate acidifies the noncarbonate soils of Southern China. The results of recent field experiments in red earth districts have also shown that row application of the fertilizer to barley at the rate of 30 tszin/mu strongly acidifies the soil around the roots of the plants (pH about 3 to 4) and results in their death after germination. Ammonium chloride is even more potent than ammonium sulfate. If the required amount of lime is added to the soil during plowing, both ammonium sulfate and ammonium chloride increase the yield of all crops (13, 19).

Chen' Shan-din and others (39) have pointed out that the effect of ammonium chloride on the carbonate soils of Northern China is the same as that of ammonium sulfate. It was shown to have had no adverse effect over a period of ten years on the physical or chemical properties of the soil. The experiments of Yuy Daomin' (43) with urea and ammonia nitrogen under wheat on fields with a great deal of burnt earth used as a basic fertilizer have shown them to be equally effective.

Limitations on the use of cyanamide Ca($CaCN_2$) were noted long ago. Composting it with silt and other fine-grained substances under favorable hydrothermal conditions accelerates the formation of urea and ammonia nitrogen and a little 2CN x NH_2 (51).

Chen Shan'-din' (40) and Lin Guan-zhuy (11) conducted experiments with ammonia water on carbonate soils in Northern China. The results showed that it is highly effective when added to irrigation water (in concentrations of less than 1:10,000) or when the soil is cultivated. Experiments involving the addition of ammonia water to corn in the vicinity of Peiping indicate that it may be almost as effective as ammonium sulfate. Spraying ammonia water on plants, however, often causes yellowing of the leaves.

Use of Phosphate Rock and Fixation of Phosphorus in the Soil. The past ten years have witnessed the discovery of several large beds of phosphate rock. Experiments were performed on acid soils to determine the possibilit of using it as fertilizer (14, 30, 51, 41). As a result the degree of effectiveness of various types of phosphate rock on acid and carbonate soils is now known. Most of these experiments involved the use of uniformly ground phosphate rock containing 3.5 to 4 times more phosphoru than superphosphate. It was demonstrated that superphosphate in the first and second years is more effective than phosphate rock both on acid and on carbonate soils (14, 30, 51, 41). Ground phosphate rock is more effective only when applied for a long time on strongly acid red earth

Li Chen-kvey showed that ground phosphate rock is most potent when used on radishes, rape, and buckwheat, less so on *Crotalaria anagyrodes, Sesbania canabina, Lespedeza sp.* sweet potatoes, and beans, least of all on whea rye, oats, and clover. Most investigators believe that it is particularly effective when adde to a field of green manure. Se Tssyan-chan and others have proved that ground phosphate rock is less effective when used on radishes, soy beans, *Phaseolus aurea Roxb*, buckwheat, wheat, tomatoes, oats, alfalfa, barley, and rice.

Soluble phosphates added to red earths after they dry out are almost totally converted into an unavailable form (51). The investigators believe that ferrous phosphate and aluminum phosphate are easily assimilated only when in the liquid phase, but after dehydration they turn into forms unavailable to plants, and this reaction is irreversible. However, we cannot emphasize too much the fact that phosphorous fertilizers are strongly fixed by acid soils since the results of field experiments have shown that superphosphate is effective on crops even on highly acid red earths.

Chinese peasants have many effective ways of applying phosphorous fertilizers, e. g., for rice they use concentrated amounts in seedbeds, wetting the roots of the sprouts. Field experiments have demonstrated the value of their methods (51).

Adding large quantities of phosphorous fertilizer to the seed plots of peanuts makes it possible to obtain seeds with considerable phosphorous content. When planted in red earths poor in phosphorus, they may reduce the phosphorous requirement and increase the ld (51).

Experiments with foliar feeding were begun
Pen Tszyan and others (51) in 1951 in the
ıthern part of Tszyan'su province. The re-
ts showed that spraying small amounts of
ɔerphosphate (0.8 tszin/mu) on strongly
d and phosphorus-poor soils is effective in
reasing wheat and rice yields. Experiments
re subsequently performed on many experi-
ntal fields, but the results were too conflict-
to be conclusive. A perceptible effect was
served only in connection with cotton. For
ample, in 1954 there was an average increase
yield of 21% on four experimental plantations
, 26).

Potassium Fertilizers. Mass analyses have
wn that the total K_2O content in the soils of
rtheastern and Southern China is 1.8%-2.6%
ile that of exchangeable potassium is 8-15 mg
100 g of soil. South of the Yangtse River
acid soils containing about 0.5% K_2O. How-
er, on some soil-forming parent material
h in mica and potassium feldspars the K_2O
ntent also comes to 1.0%-2.0%. China uses
nost no commercial potassium fertilizers,
serving as such. Experiments run for
ny years indicate that the use of potassium
tilizers for wheat and some other crops is
ffectual. Only certain sandy soils show a
assium deficiency. In addition, such crops
sweet potatoes, soy beans, peanuts, tobac-
etc. require potassium.

The need of potassium fertilizer to obtain high
lds is increasing. In 1958 it was shown that
and other potassium and phosphorous fer-
zers substantially contribute to increased
ld and resistance to etiolation of rice and
eat.

Liming of Acid Soils. The literature on
ing acid soils is quite extensive. In recent
rs field experiments have yielded accurate
rmation on the amounts of lime needed for
erent crops on a variety of soils. In 1958
research in Guandun and Guansi provinces
) revealed that prolonged liming of the top
cm of soil raises the $CaCO_3$ content to 5%-
with the formation of compact plates of lime
he subarable horizons. Proper liming of
d soils is now essential and improvement
soils with compact lime horizons is a major
blem in Southern China.

Local Peasant Fertilizers. Commercial
tilizers were introduced into China only 40
rs ago, and even now they are not widely
ployed. Fertility has been maintained for
usands of years chiefly by local peasant
tilizers. These include residues of cultivated
uncultivated plants, green manure, excre-
nt and urine of animals and man, lake and
er silt, sod, burnt earth, ash, etc. They
e been employed separately and in combination after aerobic or anaerobic composting. During the past ten years the research organizations of various provinces have done a tremendous amount of work on composting, preparation and preservation, and methods of use.

Many new summer green manures and cover crops like Crotalaria angyrodes, Phaseolus aurea Roxb, and others were planted in the red earth districts of the southern provinces of the country while work was continued on winter green manures and methods of using them (8, 1). It is desirable to grow Phaseolus mungo, black beans, sweet clover, etc. in the northern part of the country with one wheat crop a year as a summer green manure. Plowing under these crops increases the yield 39%-60%. Furthermore, good results were also obtained by growing Sesbama canabina pers, Trigonella fosenum graccum, Amorpha, and tamarisks (51).

In 1958 the principal soil science and fertilizer organizations carried out large-scale work in describing local and peasant fertilizers throughout the country, studying their useful features and methods of preparation.

Ten years of leadership by the Chinese Communist Party and its constant concern for the advancement of science as well as the help afforded by Soviet scientists have made radical changes in soil science and agricultural chemistry. Nevertheless, there is still much to do by way of accelerating the development of socialism in the country.

The expansion of agriculture has confronted soil science with many new problems. They require the chemists and soil scientists to continue to learn advanced techniques in the Soviet Union and to study cultivated soils in more organized and systematic fashion by blending scientific theory and practice on the basis of peasant experience. We are confident that under the guidance of the Chinese Communist Party and with the help of scientists in the socialist countries our agricultural chemists and soil scientists will ultimately achieve even greater success.

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METHODS

OLONETZATION OF CHESTNUT ZONE CARBONATE OILS IN KAZAKHSTAN

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Chestnut carbonate soils are widespread Kazakhstan on the vast territory from the rth of the Caspian Lowland to the Altay foot-lls. The vast majority of these soils have cal features characterizing their structure d chemical composition.

Chestnut carbonate soils have been described many investigators since the studies of the igration Board (12, 15, 16, 17, 24, 25, 39, 49, 51, , 56, 57). Much material has been accumuted recently in connection with detailed soil udies by the Ministry of Agriculture of the zakh SSR and the research establishments the Republic in districts where virgin or andoned lands have been brought into cultivan. The present article is an attempt to exain the causes of local features in chestnut rbonate soils in Kazakhstan based on some these materials.

The chestnut soil zone in Kazakhstan has a arkedly continental climate with a prolonged vere winter, a hot dry summer (Table 1) d a mean annual precipitation of 250-300 mm. e vegetative cover in this extensive region is mparatively uniform and consists of grass eppe in which *Stipa capillata* and *Festuca lcata* predominate.

Chestnut soils form on the most varied ref (the pre-Caspian Lowland, the Mugodzhar ountains, the Tengiz depression, the central zakhstan low hill district (melkosopochnik) d the Irtysh plain). The soil-forming rocks e geological formations of the most varied igin, age and petrological composition — om the marine sediments of the Caspian plain the sandy alluvium of the Irtysh.

The main local features of these soils inde thinness, tongue formation and a more rrow carbon-nitrogen ratio than in similar ils in the western provinces. Conditions e also created in this arid climate for the cumulation of calcium carbonate on the minalization of dead vegetation. The widespread stribution of carbonates of secondary origin and carbonate chestnut soils are therefore typical features of the Kazakhstan soil province.

Carbonate soils in the chestnut zone are associated with soil-forming rocks of fine texture, which are not common in the central Kazakhstan arid steppe and the Nura-Tengiz depression. Our description of carbonate chestnut soils is based on these districts.

The soil-forming rocks are mainly loess-like gypsiferous clays of Quaternary age containing some salts, mainly chlorides and sulfates (Table 2). The calcium carbonate content of loess-like clays is comparatively low (1.5%-5%). Tertiary deposits (the reddish-brown clays of the Pavlodar Shield and the greenish Neogenic clays of the Aral' Shield, etc.) are of secondary importance in soil formation and also have a low carbonate content. The salinity and gypsum content may be considerable.

Carbonate chestnut soils are normally zonal and ground-water plays no part in soil formation. The thickness of the profile is reduced. The entire soil profile is 80-120 cm and the upper (A) horizon, which usually fluctuates between 15 and 18 cm, rarely reaches 20-25 cm. The profile is greatly compressed and of a uniform greyish-brown-cinnamon color, the transitions between the horizons being indistinct and often irregular. The soil stratum is broken up by large vertical fissures that are often several centimeters wide at the surface. Quite large hummocks are formed when the edges of these fissures crumble as the soil shrinks. This hummocky structure, that is typical of carbonate soils, is widely distributed.

Deposits of calcium carbonate, which is present to a lesser extent from the surface down, are to be found (often as concretions) in a horizon at a depth of 40-100 cm. The main feature of most of the carbonate soils of Kazakhstan, however, is a clearly defined solonetz horizon with a marked prismatic structure, that is often nutty to blocky. This horizon has a brownish

Table 1

The main climatic indices of chestnut zone soils in Kazakhstan

Observation station	Mean annual precipitation, mm	Mean annual air temperature °C	Annual temperature range, °C	% continentality	Arid steppe zone	
					Evaporation, mm	Evaporability
Karkaralinsk	297	2.4	31.9	—	—	—
Akmolinsk	260	1.4	31.8	70	240—550	600—1100
Aktyubinsk	275	3.6	38.2	58	—	--

Table 2

The main climatic indices of chestnut zone soils in Kazakhstan

Parent material and boring site	Particle diameters		Chemical composition	
	<0.01 mm		Calcium carbonate (CO_2)	Total water-soluble salts
Yellow brown loess-like clay. Yessil' district. Akmolinsk region.	60.12	22.4	1.5	0.820
Yellow brown loess-like clay. Nurinsk district. Karaganda region.	48. 5	35.4	4.5	0.660
Grey Tertiary clay. Yessil' district. Akmolinsk region.	67. 7	43.4	3.2	0.157
Reddish-brown Tertiary clay. Tavriz district, Vostochno-Kazakhstanskaya Oblast'	70. 6	43.1	2.3	0.916

tinge and the surfaces of the structural units are shiny. It is not the carbonate content but the solonetzation of these soils that determines their physical properties in relation to water.

The relationship between carbonate soils and parent material of fine texture should be noted, since they are not normally formed on a coarse texture. There is a striking migration (Table 3) of the colloid fraction to the central and lower parts of the profile, which is typical of solonetzic soils (except for areas underlain by coarse texture material). The carbon-nitrogen ratio is already noticeably different from similar soils in the western provinces (Table 3) but the remaining chemical indices are typical of chestnut soils. In the majority of cases the adsorption soil complex contains adsorbed sodium (Table 4), often in quantities that are typical of solonetzic soils. In addition there is an increased quantity of adsorbed magnesium in some profiles that may be the cause of magnesium solonetz. This phenomenon has been repeatedly mentioned in the literature (3, 7, 22). In describing the smolnitsa of Albania, Bogatyrev links their high mechanical strength, blocky structure and vertical fissuring with magnesium solonetz. Similar morphological characteristics are also encountered widely in carbonate chestnut soils in Kazakhstan with an increased magnesium content. An examination of the extensive factual material leads, however, to the conclusion that, in the modern stage of their development, solonetzation has declined in carbonate soils. This is shown by the generally comparatively low level of adsorbed calcium and magnesium, by the thoroughness with which simple salts have been washed out and by the rapid degradation of th solonetzic horizon on cultivation. The enhanced level of water-soluble salts often observed in the lower part of the profile is due to the salinity of the soil-forming parent materials. The enhanced total alkalinity (Table 3) in a considerable number of samples is also a feature of solonetz soils.

The calcium carbonate content and its distribution throughout the profile of carbonate chestnut soils (Figure 1) is of particular inte est. The upper horizons contain comparative little calcium carbonate (up to 3%). The max mum concentration (up to 10%) is reached at depth of 20-100 cm, after which it declines rapidly with increase in depth (3%-5%. The accumulation of calcium carbonate in the mic

Table 3

Physicochemical composition of chestnut carbonate-solonetz soils

Pro- file No.	Profile site	Depth, cm	Total humus	Total nitr.	C:N	Available phosphorus mg per 100g	Particle diameter,%		Water extract, %				
			In %				<0.01 mm	<0.001 mm	Residue	Total alkalinity	Partial alkalinity	Cl^-	$SO_4^=$
281, 956	Ulansk dist. Vostochno Kazakhstan-skaya Oblast'	0—10	3.8	0.27	8.1	28.5	51.8	31.8	0.048	0.043	None	0.002	0.007
		25—35	2.6	0.19	7.9	10.3	61.4	38.5	0.044	0.043	"	0.001	0.005
		55—65	0.6	0.10	3.4	—	18.5	13.2	Not det'd.				
		90—100	—	—	—	—	23.8	16.1	"				
		120 –130	—	—	—	—	31.0	19.1	"				
		140—150	—	—	—	—	Not det'd.		0.458	0.039	None	0.061	0.211
203, 957	Tavriz dist. Vostochno-Kazakhstan-skaya Oblast'	0—10	4.94	0.30	9.5	35.2	63.6	30.2	0.069	0.038	"	None	0.002
		14—24	3.91	0.24	9.4	17.7	71.0	37.4	Not det'd.				—
		25—35	2.95	0.19	9.3	17.3	73.3	40.3	0.075	0.046	„	„	0.005
		40--50	2.16	0.13	9.1	—	74.7	45.0	Not det'd.	---	„		—
		80—90	—	--	--	—	88.9	62.0	0.813	0.020	„	0.061	0.450
		150—160	--	—	—	—	87.6	64.4	0.508	0.031	„	0.159	0.101
160, 955	Nurinsk dist. Karaganda Oblast'	0—10	3.82	0.25	9.0	18.0	60.0	37.9	0.100	0.028	None	0.005	0.008
		14—18	2.02	—	—	—	—	—	0.208	0.033	„	0.005	0.007
		35—45	1.31	0.16	5.4	18.0	44.1	28.8	Not det'd.				
		55—65	0.52	—	—	—	54.5	34.5	"				
		140—150	—	—	—	—	48.5	35.4	"				
117[a]	Yessil' dist. Akmolin-skaya Oblast'	0—10	4.46	0.31	8.2	61.0	48.5	16.6	0.133	0.054	None	0.007	0.031
		25—35	3.10	0.25	7.3	43.0	49.8	16.6	0.168	0.064	"	0.007	0.065
		55—65	2.31	—	—	—	53.4	19.2	0.199	0.082	"	0.023	0.065
		70—80	1.41	—	—	—	61.5	23.9	0.321	0.071	"	0.084	0.119
		95—105	0.98	—	—	—	41.92	16.9	1.991	0.023	"	0.094	1.506
		140—150	0.46	—	—	—	41.57	13.7	1.007	0.076	"	0.068	0.717
241[a]	Yessil' dist. Akmolin-skaya Oblast'	0—10	4.53	0.43	6.0	22.9	70.3	30.43	0.105	0.058	"	0.004	0.008
		13—23	4.15	0.39	6.2	21.4	68.3	38.70	0.127	0.061	"	0.004	0.008
		35—45	1.17	—	—	—	74.2	44.38	0.136	0.073	"	0.004	0.008
		75—85	1.28	—	—	—	74.14	42.55	0.272	0.064	"	0.098	0.075
		105—115	0.60	—	—	—	77.07	41.45	1.707	0.035	"	0.127	0.679

ote: Profile Nos. 281, 203, 160 are the author's materials. The analysis was made at various laboratories in Alma Ata on the instructions of the Alma Ata land organization expedition of the Ministry of State Farms of Kazakh SSR.

[a] Materials of the soil science faculty of Kazakh State University. Profile No. 117 was analyzed 7 A. Kurmangaliyev; cross-section 241 by V. A. Yevsyukova.

nd upper profile cannot be explained by up- ard migration from the parent material, in iew of its slight mobility and small content. is clear that this calcium carbonate is main- of secondary, biogenetic origin. Similar rigination in desert zone soils has been proved a number of papers (35, 36, 58, etc.). In the rid steppe of the chestnut zone, where the oil is "semi-leached" (according to Lobova, 6), biogenetic calcium carbonates accumu- ate at some depth, whereas in desert soils ey accumulate from the surface down. Hence is quite clear that the carbonate soils are associated with clay parent materials which favor the accumulation of secondary carbonates in the upper horizons owing to their low permeability. The less moist soils of the southern slopes also effervesce more in hydrochloric acid.

The secondary nature of the carbonates explains the combination of solonetzation and carbonates in these soils. Soils that became solonetz in the past have been subjected, in addition to stabilization, to the formation of secondary carbonates owing to the arid climate

Table 4

Composition of adsorbed bases of carbonate-solonetz chestnut soils

Depth, cm	Adsorption capacity, meq per 100 g	Ca	Mg	Na	Ca	Mg	Na
		Meq per 100 g of soil			As a % of absorption capacity		
Profile No. 281							
0—10	25.0	23.4	1.2	0.6	93.6	4.8	1.6
25—35	23.4	21.9	1.9	None	94.0	6.0	0.0
55—65	11.4	Not det'd.					
Profile No. 203							
0—10	31.7	26.2	5.1	0.5	83.5	16.2	1.3
14—24	31.1	22.6	8.3	0.3	72.6	26.5	0.9
25—35	28.0	18.4	9.6	None	65.7	34.3	0.0
Profile No. 117							
0—10	23.7	19.5	6.6	0.6	72.9	24.7	2.4
25—35	32.6	26.0	4.4	2.2	79.5	13.8	6.71
Profile No. 241							
0—10	33.1	26.1	3.0	3.9	78.8	9.3	11.9
13—23	29.6	23.9	2.0	3.3	80.7	8.1	11.2
35—45	32.4	24.9	2.3	5.1	77.0	7.2	15.8

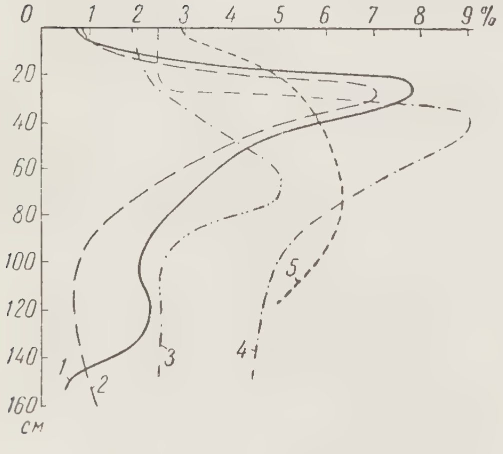

Fig. 1. - Content and distribution of carbonate CO_2 in chestnut carbonate-solonetz soils.

1 - Profile No. 281; 2 - Profile No. 203;
3 - Profile No. 117; 4 - Profile No. 160;
5 - Profile No. 241.

and the clay parent materials. Solonetzic features are clearly retained everywhere.

The origin of provincial features in the chestnut soils of Kazakhstan becomes partly clear if we examine the historical development of Kazakhstan in the Quaternary era as outlined in Table 5, compiled from the data of many workers (2, 4 5, 6, 9, 10, 17, 32, 33, 37, 38, 41, 42, 43, 44, 45, 5 59) and from my own recent data.

Savannas similar to those found today covered central and northern Kazakhstan in the Pliocene. It is evident that red earths w widely distributed at this time. These red e provided the reddish tinge to be found in plac in the clays of the Pavlodar Shield, in the de posits of which one finds the spores and polle of savanna vegetation (19, 46, 47) and the Hip parion mammalian fauna (1). The low carbo ate and high sesquioxide content in Quaterna sediments (clay loams) is due to the existen in the Pliocene of red earths that were subsequently eroded and redeposited. These sediments were evidently made saline during the erosion of marine and estuary Tertiary strat Considerable upraising of blocks probably to place at the dawn of the Quaternary Era in th vicinity of the central Kazakhstan block. Th movements caused intensive erosion of earli sediments. In early Quaternary times (Eopl tocene) the eroded areas along the edge of th low hill country and its low-lying parts bega to be overlain with deluvial-proluvial clay loams and clays. There is reason to think that there were semi-desert soils of chestnu type at this time. Fossilized remains of thi type are found in the lower part of the depos and the pollens of the period contain xerophy species (40). With the onset of the Ice age,

Table 5

Outline of the historical development of chestnut zone soils in Kazakhstan

Geological period	Conditions of soil formation				Soils
	Climate	Parent materials	Relief	Vegetative cover (according to Zaklinskaya, 19)	
Holocene	Markedly continental, arid		Partial erosion of watersheds, deflation	Temperate flora, similar to the contemporary flora	Stabilization of soils and subsequent carbonation of the residual solonetz soils
	Warm, dry	General afforestation of clays	Lowered erosion level	—	Soils become generally solonetzic
Pleistocene	Cold, dry	Deposition of alluvial clays, deposition of proluvial-deluvial clays	Further cutting of the river network, leveling of watersheds	Coniferous forests in river valleys, open associations, grasses, shrubs	Formation of bog and saline (solonchak) soils from flooding in Ice ages
Eopleistocene	Warm, dry	Deposition of deluvial-proluvial alluria commences	Formation of contemporary river network commences	Temperate flora, semidesert vegetation	Steppe soils of chestnut group
Pliocene	Warm, mildly humic	Tertiary sediments and ancient undisturbed rocks, strongly-eroded owing to tectonic upheavals in the low hill region	Dissected	Temperate flora, savanna vegetation	Red earths, reddish-brown soils

affected the Asiatic territory of the USSR most in the Pleistocene (6, 26, 27, etc.), the climate became much colder. It has been proved that the territory was not covered by the ice sheet but was heavily flooded by Siberian rivers swollen by the Ural-Taymir ice sheet. Clay loams and clays were laid down by the meandering water courses on the southern edge of the West Siberian Lowland and the Turgay plains, where the waters of the Ob and Irtysh found temporary outlet in the Aral-Caspian Basin (5, 13, 6, 28, 37). Bog and saline (solonchak) soils, the formation of which is due to excess water, especially ground water, and to the high salinity of the eroded Tertiary deposits, predominated. After the Ice ages there was an xerothermal stage (2, 12, 13), as a result of which the deposits became carbonated and the soils heavily saline. As the moisture of the climate increased and the erosion level decreased, there was a stage in which solonetzation was widespread and the sodium type of salinization predominated. Since that time and down to the present there has been continual stabilization of the solonetz soils from the water-sheds to the depressions and secondary carbonation of biogenetic origin has occurred.

This is a general evolutionary outline of the soils of the chestnut zone in the light of geological and paleogeographical data. The author has examined a special case of this evolution (17).

It seems natural that, because of their morphogenetic and physicochemical features and the nature of their origin in Kazakhstan, chestnut carbonate soils should be assigned to a special class in the genetic classification. Several such attempts have been made (see the work of the soil science faculty at the Kazakh State University (15) and of the Institute of Soil Science of the Kazakh Academy of Sciences (54). Solonetz carbonate chernozems have been distinguished in the trans-Ural region by Karatayev (29). Solonetz carbonate soils are often distinguished (and sometimes further subdivided) on the large scale soil maps produced by economic organizations. For some inexplicable reason however many soil scientists still ignore the very apparent solonetz features in the carbonate soils of Kazakhstan (16, 18, 49, 57). Carbonate solonetz soils that actually exist are not usually distinguished on large scale soil maps produced by research organizations.

In my opinion those carbonate soils of the chestnut zone in Kazakhstan that have clearly defined solonetzic features should be assigned to a special class of carbonate-solonetz soils. This title would stress the primary nature of the solonetz and the secondary nature of the carbonation in the formation of these soils, which may be further subdivided into weakly carbonate-solonetz soils, and highly carbonate-solonetz soils.

Economic Significance of Carbonate — Solonetz Soils

Carbonate-solonetz soils make up the majority of the plowland in a number of districts in which virgin and abandoned lands are being brought into cultivation (Akmolinsk, Karaganda and south of the Kustanay Oblasts). Deeper study of their origin and physicochemical and other properties therefore has direct bearing on increasing grain production in the Republic. This study, plus the experience gained in cultivating the soils, is essential to the evolution of rational measures for improving their fertility.

This article has not been concerned with detailed examination of the agricultural aspects, but the general requirements follow from what has been said previously. The approach to cultivating these soils should be such as to accelerate desolonetzation and to improve the unfavorable physical properties in relation to water caused by solonetzation. The soil must therefore be deeply cultivated to disrupt the solonetzic horizons and must be strongly wetted. Under these conditions the enhanced natural calcium carbonate content may help to displace the adsorbed sodium (31). Correct farming methods can thus improve the fertility of carbonate-solonetz chestnut soils and considerably increase their yield.

Conclusions

1. Carbonate-solonetz chestnut soils are a large part of the soils in the chestnut zone of Kazakhstan. They possess special features, owing to the presence of a solonetzic horizon.

2. The solonetzation of these soils is a relict and arose from their development from bog and saline (solonchak) to solonetz and stabilizing soils in present day conditions. Carbonates in them are of secondary origin.

3. In view of the physicochemical features that have arisen in the development of these soils it is suggested that they should be called carbonate-solonetz soils and be subdivided int weakly carbonate-solonetz, carbonate-solonet and strongly carbonate-solonetz chestnut soils

Received September 25, 1958

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BURIED SOILS OF THE MIDDLE AND UPPER OLIGOCENE OF KULUNDA

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The paleogenic buried soils of Western Siberia have not been given enough attention in the special literature, although a knowledge of them would provide a deeper understanding of the development of the landscapes of Siberia in the Paleogenic. In this paper we describe the morphology of the Middle and Upper Oligocene buried soils on the basis of numerous core samples dug by the Steppe Expedition of the Western Siberian Geological Administration.

Buried soils were found among strata of the Atlymsk, Novomikhaylovsk, and Zyat'kovsk sub-suite of the Nekrasov suite (continental rocks of the Middle and Upper Oligocene.[1]

Buried soils of the Atlymsk Sub-suite of the Nekrasov Suite (Middle Oligocene)

Buried soils of this suite were found by us in only one hole (hole 36, Dem'yanovka, absolute elevation 143 m), located on the modern Pavlodar plateau. The description is as follows:

1. Meadow-bog soil, Hole 36.

A 125.9-126.4 m Darkish clay.

A_1A_2g[2] 126.4-127.3 m Whitish-grey clay with blue tinge. Yellow-brown sand below.

2. Bog soil, Hole 36.

Ag 138-138.5 m Greyish clay with bluish tinge. Remains of roots of bog vegetation.

g 138.5-147 m Whitish-greyish-blue clay. Brown sand lies below.

These soils are non-carbonate, low in humus, sometimes contain the remains of the roots of bog vegetation. The humus horizon is as much as 0.5 m thick. The whitish color below the A horizon indicates that there may have been a temporary podzolization and gleyization. Carbonates and peat are not present. Both soils are underlain by brown sand. We may assume that these soils developed in a fairly moist climate, which meant the removal of the mineral products of soil formation and the mineralizing plant residues (for example, carbonates) from swampy depressions. The absence of peat in the profile of the bog soils means that clayey, swampy hollows were present in the landscape. The periodic alternation of relatively thick layers of sand and clay emphasize the fact that the buried soils are found in a region characterized by periodic activity and stagnation of water in a region of local swamping. Apparently the bog soils formed and were buried in regions affected by the waters of river deltas. This assumption is confirmed indirectly by the fact that in the vicinity of Hole 36 before the formation of the soils in question plant residues were buried and formed brown coal. In addition we must take into account the fact that coal formation extended even into surrounding areas (for example, in the region of Galkino settlement, Pavlodar Region, hole 26). The soils of the Atlymsk sub-suite, which were found in hole 36, developed in a humic zone of deciduous forests, in a lowland, in the region of a river delta, where perhaps there was severe swamping and periodic burial of the swamps by river sand.

Buried Soils of the Novomikhaylovsk Sub-suite of the Nekrasov

Among the strata of the Novomikhaylovsk sub-suite we found a considerable amount of buried soils in the contemporary Pavlodar Plateau along its northern margin, and in central Kulunda.

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[1] Age of strata determined by Geologist I. G. Zal'tsman.

[2] g signifies gleyed horizon.

The buried soils were bog, meadow-bog, meadow, podzolic soils, and also soils of the solonetzic group. Their description follows.

Bog Soils. The bog soils are relatively similar in form. Only eight types were distinguished among them, namely:

1. Hole 33 (Chainka settlement, south of Lake Azhbulat).

Ag 115-115.5 m Rather dark clay with dark-blue tint and $CaCO_3$ concretions.

Cg 115.5-116 m Grey with dark-blue tint of carbonate clay.

2. Hole 33.

Ag 116-116.5 m Rather dark clay with dark-blue tint. Spots of $CaCO_3$.

g 116.5-119 m Light-blue clay with rust-colored spots. Below (119-122 m) there is green clay, giving way (122-131 m) to blue sand.

3. Hole 33.

A 132.5-133 m Dark clay without carbonates.

Cg 133-133.5 m Blue-grey clay with spots of $CaCO_3$. Below is found a soil similar to that mentioned.

A similar soil was found in Hole 37 (Belousovka settlement, south of Lake Azhbulat) at a depth of 165 and 165.4 m.

4. Hole 33.

A 135-135.5 m Darkish grey soil.

Ag 135.5-136 m Greyish dark-blue clay.

g 136-136.5 m Lighter dark-blue clay with rust-colored spots.

5. Hole 32. (Alga settlement, Pavlodar Plateau, absolute elevation 143 m).

A 106.7-109 m Greyish clay.

g 109-113 m Bluish-greyish clay.

Cg 113-114.5 m Dark-blue clay with $CaCO_3$ concretions, transitional to lighter dark-blue clay with concretions and veins of $CaCO_3$. Below lies buried meadow soil 2.

6. Hole 37 (Belousovka settlement, south of Lake Azhbulat).

A 162.8-163 m Dark carbonate clay with remains of root system of herbaceous vegetation.

g 163-165 m Greenish clay. Below lies a bog soil similar to soil 3.

7. Hole 42 (Belotserkovka settlement, absolute elevation 139 m, south of Lake Azhbulat

A 154.5-155 m Dark clay.

g 155-158.5 m Bluish-greyish clay. Similar soils were found below (158.5-170 m), and also in Hole 42 at a depth of 172.8-173.5 m

8. Hole 42.

Ag 170-170.2 m Darkish-deep-bluish cla

Ag 170.2-171 m Greyish dove-colored clay. Below (171-172.8 m) there is a buried meadow soil (type 4).

Thus the bog soils are low and average in humus. The humus accumulates in a layer 0.2-2.3 m thick. Carbonates may or may not be present in the soils. Where they are present, the $CaCO_3$ accumulates in the form of concretions, spots, and veins. The carbonate are found low down, high up, or over the whole soil profile. The bog soils are fine-textured. Often we observe subsequent formation and burial of bog soils without interventing strata (cf. above).

Meadow-bog soils. The meadow-bog soils are not described as soils transitional from bog to meadow.

Meadow soils. There are four types of meadow soils.

1. Hole 33.

A 112.8-113.4 m Dark clay.

AB 113.4-114 m Darkish-grey clay.

Cg 114-114.5 m Bluish-grey clay with rust-colored spots of R_2O_3 and spots of $CaCO_3$.

Below (114.5-115 m) there is a bluish-grey non-carbonate clay with rust-colored spots. A similar soil was found in Hole 23 at a depth of 107.5-112.8 m, but in this the carbonates were in the form of concretions, spots, and veins.

2. Hole 32.

A 114.5-115 m Dark clay.

AB 115-115.8 m Grey clay.

g 115.8-117.7 m Bluish-grey with grey veins along the fissures and capillaries.

g 117.7-119 m Dark-blue clay.

3. Hole 31. Rozhdestvenka. Central Kul- ıda.

A 163.5-164 m Black clay.

AB 164-164.3 m Dark-grey clay.

AB_2 164.3-168.9 m Grey-silty clay.

Below there is a layered greyish silty clay. milar to soil 3 found in Hole 37 at a depth of 32.6 m.

4. Hole 42.

A 152-152.2 m Black clay.

AB 152.2-153 m Greyish with remains roots of herbaceous vegetation.

Below (153-154 and 171-177.8 m) there are eadow soils similar to this type.

Thus the buried meadow soils in question are oderately or strongly humic. They have early defined A and AB horizons. The A hori- on is 0.2-0.6 m thick. The soils are non- rbonate or carbonate. In the latter, the rbonates have accumulated in the lower rt of the profile in the form of spots. Gleiza- on is not found (soils 3 and 4) or occurs in the wer part of the soil profiles (soils 1 and 2).

Podzolic Soils

Buried podzolic soils were found only in le 37:

1. Podzolic soil, Hole 37.

A 159.6-159.8 m Dark clay with plant re- ains.

A_2 159.8-160 m Greyish-whitish clay lay loam).

g 160-162.8 m Green clay.

The podzolic soil, apparently, can be de- gnated as a typical gleyed-podzolic soil.

Soils of the Solonetzic Group. Solonetzic ils were identified by the presence of a sol- etzic structure — clearly delimited large d small nut-like and acute-angular aggre- tes with a shiny surface. The last character- ic differed with the stratum, with the nature the colloidal film on the surface of the aggre- tes. Below are described two different types solonetzic soils.

1. Hole 32.

A_1 119-119.5 m Grey layered silty clay (clay loam).

A_{sn} 119.5-120 m Black clay with nut-like structure.

SN_2[3] 120-120.5 m Chocolate-colored clay with less clearly defined nut-like structure.

g 120.5-121.5 m Light-grey clay, transitional (121-121.5 m) to bluish-grey clay.

2. Hole 33.

A_{sn} 134.3-134.8 m Dark clay with nut-like structure.

g 134.8-135 m Greenish deep-blue clay.

Below there is a buried bog soil. The solonetzic soils contain low, moderate, or large amounts of humus. They can be assigned to the meadow-bog and bog solonetzic soils. As to depth of the solonetzic horizon they may be classed as crusty (surface, type 2) and deep (type 1) solonetzic soils. But it may be that the A_1 horizon should be classified as type 1, since it shows a clearly laminar structure. At the same time the laminar structure may be associated with solodization. It is quite possible that the nut-like structure developed in the manner of the modern flood-plain, non-solonetz, meadow soils. The buried soils of the Novomikhaylovsk sub-suite differ from the buried soils of the Atlymsk sub-suite in that they show local carbonation, solonization (?), podzolization, or solodization (!!).

Buried Soils of the Zyat'kovsk Sub-suite of the Nekrasov Suite (Upper Oligocene)

Buried soils of the Zyat'kovsk sub-suite were identified in six borings.

The following is a description of the buried soils:

Bog Soils. There are three types of bog soils, namely:

1. Hole 31.

A_1 147.5-148 m Darkish-grey clay.

Ag 148-149 m Greyish deep-blue clay.

Below (149-149.5 m) we find greenish sand, underlain by light greenish (149.5-150 m) and green (150-151 m) clay. Soils similar to this were identified in Hole 34 at depths of 86.4-90 and 102-105 m.

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[3] SN horizon means solonetzic horizon.

2. Hole 31.

A 151.5-151.9 m Darkish deep-blue clay.

Cg 151.9-153.5 m Light-greyish-blue clay with spots of $CaCO_3$.

Cg 153.5-154.7 m Greenish clay with a small number of spots of $CaCO_3$. Below there is a meadow-bog soil.

3. Hole 36.

Ag 109.6-111.9 m Darkish deep-blue clay.

Cg 111.9-114 m Mottled (greyish-blue and rust-colored spots) clay with spots and veins of $CaCO_3$.

Cg 114-125.9 m Greyish-blue clay with occasional spots of $CaCO_3$, disappearing downwards.

Consequently, the bog soils in this subsuite are low in humus, being humified to a depth of 0.4-2.3 m. They are non-carbonate or carbonate in the lower part of the profile.

Meadow-Bog Soils

Two types of meadow-bog soils were identified:

1. Hole 32.

A 103-104.8 m Dark clay.

ABg 104.8-105 m Grey clay with dark-blue tinge.

g 105-105.9 m Greyish-blue clay.

Cg 105.9-106.7 m Greyish-blue carbonate clay.

2. Hole 31.

AC 154.7-155 m Dark-grey clay with spots of $CaCO_3$.

ABC 155-155.2 m Grey carbonate clay.

Cg 155.2-155.4 m Greenish-deep-blue clay with spots of $CaCO_3$.

C 155.4-155.6 m Whitish greyish-blue non-carbonate clay with concretions of $CaCO_3$.

The meadow-bog soils are slightly or moderately humic.

The A horizon is 0.3-1.8 m thick. Carbonates are present over the whole profile or in the lower part of the soil profile. Gleization is pronounced below the humified part of the soil profile.

Meadow Soils

The meadow soils were few and five types were identified.

1. Hole 34.

A 96.8-97 m Dark clay.

AB 97-100 m Grey clay.

g 100-102 m Light deep-blue clay.

2. Hole 31.

AC 155.6-156.1 m Darkish clay with veins of $CaCO_3$.

ABC 156.1-156.6 m Gray clay with a large number of veins of $CaCO_3$.

Cg 158.6-160.5 m Light deep-bluish clay with veins of $CaCO_3$.

3. Hole 40. Vorontsovka settlement. Northern Kulunda.

A 130.2-131.7 m Dark-grey clay with cinnamon-brown tinge.

ABg 131.6-135.9 m Grey clay with greenish tinge.

4. Hole 42.

A 127.5-128 m Cinnamon-brown grey sands.

AB and the stratum from 128-152 m Grey sand.

5. Hole 31.

A 163.5-164 m Black clay.

AB 164-164.3 m Darkish-grey clay.

B 164.3-168.9 m Grey silty clay.

Below (176-181.3 m) there is a layered, silty clay.

The meadow soils of this sub-suite developed on clays and sand. They contain large, medium, and small amounts of humus. They are humified to a considerable depth. Gleization is found in clayey meadow soils in the lower part of the profile; sandy textures are not gleyed. The meadow soils are carbonate or non-carbonate, depending on the conditions of their development.

Table 1

Relation of vegetation and buried soils

Sub-suite of the Nekrasov suite	Characteristic features	
	Vegetation	Soils
Atlymsk, Middle Oligocene	Lesser role of subtropical forms and increase of Turgay forms	Development of podzolic soils on elevations. In depressions, development of clayey bog soils, meadow-bog soils, meadow soils, with carbonate horizons or without them
Novomikhaylovsk, Middle Oligocene	Increased proportion of species of Pinaceae and Taxodiaceae	
	Increased number and variety of broadleaf forms. Characteristically includes thermophilic plants (Pterocarya, Ilex, Nyssa)	Appearance of nut-like structure in some meadow-bog and meadow soils.
Zyat'kovsk, Upper Oligocene	Conifers (Pinaceae, Taxodiaceae) and broadleaf with some herbaceous vegetation (Onagraceae, Potamogetonaceae, etc.)	On elevations, development of podzolic soils; and in depressions, clayey, bog, meadow-bog, meadow soils; soils of depressions locally carbonate
	Turgay forms dominate among the angiosperms (Salix, Betula, Alnus, Tilia, etc.)	Increased quantity of water-soluble salts in the parent material.

Thus, we found among the strata of the Zyat'kovsk sub-suite soils similar to the soils of the Novomikhaylovsk.

Discussion of the Results

The buried soils of the Middle and Upper Oligocene of Kulunda (Pavlodar Region, Altay Subdistrict) are bog, meadow-bog, meadow, and podzolic soils. Their profiles are similar o corresponding profiles for modern soils. The conditions attending the development of hese soils can be reconstructed to varying degrees from the plant residues and the state f the buried soils themselves (see Table 1).

The development of podzolic soils on eleated and even depressed relief elements shows hat the climate was quite moist and supported woody vegetation. The absence of peat and he presence of carbonates in the soils of epression (at the time of formation of the trata of the Novomikhaylovsk and Zyat'kovsk ub-suite) indicate that the climate was becomng less moist going from the Middle to the Upper Oligocene. The total distribution of oils with carbonate horizons indicates the resence of local centers of carbonate accumuation. The signs of soil salinization are absent, but it has been established that the salinization of strata increases toward the Upper Oligocene. Thus, for example, if we find in the strata of the Atlymsk sub-suite 2-3 meq NaCl and Na_2SO_4 (per 100 g of material), then there will be 4-10 meq of salts (per 100 g of material) in the strata of the Novomikhaylovsk and Zyat'kovsk sub-suite. It may be that the salts have a secondary origin. But the carbonates of the soils of depressions have a primary character, since there are carbonate horizons in soils with non-carbonate humus horizons.

The presence of a nut-like structure in some meadow-bog and meadow soils indicates that the soils may have developed under a herbaceous vegetation. The genesis of the structure has not been investigated. The structure is similar in many ways to the structure of modern solonetz-like soils and even with the structure of the soils of modern river terraces. The presence of solonetzation in the soils of depressions is in agreement with the presence of carbonate accumulation. If it is shown that the structure has formed in a manner similar to these modern river-terrace soils, then we can assume that the soils in question were not subject to salinization and solonetzation.

Conclusions

1. In Kulunda during the Middle and Upper Oligocene podzolic soils developed on elevated relief and clayey bog soils, meadow-bog soils and meadow soils developed in depressions.

2. The podzolic soils are typical and sod-podzolic groups, sometimes with evidence of gleization.

3. The soils of depressions vary greatly in humus content, the thickness of the humus horizon, in gleization, and they may be non-carbonate or have carbonate horizons.

4. Among the soils of depressions we find types that resemble in structure modern solonetzic soils or the structural soils of river terraces.

5. The soils developed in boundaries of a forest zone. During the formation of the strata of the Novomikhaylovsk and Zyat'kovsk subsuite of the Nekrasov suite, conditions were favorable for the local accumulation of calcium carbonates in the soils of the depressions.

Received January 20, 1959

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VATER REGIME OF SOIL UNDER THE INDIVIDUAL CROPS F A FIELD—CROP ROTATION

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From 1950 to 1955 a study was made of the ater regime on an experimental field of the zov-Black Sea Agricultural Institute in Novoherkassk District, Rostov Region. Vyazovkiy (2) assigns the area of study to the moisure-deficient western province of Rostov egion. The annual precipitation (according to e average over many years — from 1912 to 955 — at the Persianovskiy meteorological tation) is 466 mm, though there are frequent eviations from this amount. Out of ten years 1946-1955) the precipitation exceeded the ng-term average only in 1952 and 1955, in e first case by 104 mm, in the second by 99 m; in the remaining years they were less.

Method of Investigation

The study involved a nine-field crop rotaon with a crop sequence: 1) black fallow, 2) inter wheat after black fallow, 3) spring heat with under planting of perennial grass, -5) forage, 6-7) spring wheat on once-plowed nd and on twice-plowed perennial forage land,) row crops (sunflower, corn), and 9) barley n the following fields: on black fallow, in a eld of winter wheat on black fallow under ixed alfalfa and wheat-grass, and on oncelowed land and twice-plowed land in perennial rass. On a tract of land in the experimental eld a preliminary inspection of the soil was ade. On plots similar as regards relief and il, measuring 450-500 m^2 (the latter estabshed by means of additional excavations), we ade 2 to 4 trenches 1-3 m deep, and layer by yer (the depth of a layer being 10 cm), we ok soil samples to ascertain its moisture connt. In this way we worked out the profile of e clayey, coarse, silty variety (according to . A. Kachinskiy) of northern Azov chernozem. he thickness of the humus horizon $(A+B_1)$ is) cm. The thickness of the solum $(A+B_1+B_2)$ 150 cm. There is effervescence from HCl at depth of 50-60 cm. The method of selecting d studying the plots eliminated the effect of il differences from the results. Under these nditions it was possible, by comparison, to show the effect of the individual crops on the water regime of the soil.

Mathematical treatment of data on soil moisture under individual crops obtained from various numbers of replications shows that soil tests made regularly in the field, in conformity with the objects and conditions of the experiment, even with two replications afford completely satisfactory accuracy, as shown by the data in Table 1.

The accuracy (t%) of the moisture determination in the soil profile under winter wheat after black fallow and under perennial grass on once- and twice-plowed land (thickness 0-40 cm) varies between 3.3% and 0.0% for the humus-accumulative horizon while deep down the index of accuracy reaches a maximum of 1.8%-0.0%.

Under our conditions the autumn-winter precipitation is the main source of the soil moisture. It amounts to 30%-50% or more of the annual precipitation. We must strive to have the soil make maximum use of this precipitation and the meltwater. The water from atmospheric precipitation does not, after reaching the soil, merge with the ground water; the water table here is quite deep. In the upper layer of the soil, water is stored as suspended moisture and this constitutes the main supply in the soil.

Available Moisture Supply in Soil and its Consumption During the Growing Season

The moisture regimes of the various soil horizons have special characteristics. The moisture of the upper (20-cm) soil layer undergoes the most marked changes over the whole growing season. The nature of these changes is determined by weather conditions (by the temperature of air and soil and by precipitation). At the time of shoot development, when the underground root mass first begins to develop, the state of the crop depends almost entirely on the moisture of the upper (20-cm) layer of the soil. The humus horizon $(A+B_1)$ differs from the

Table 1

Results of mathematical treatment of data on soil moisture in black fallow with varying numbers of repetitions. July, 1954

Depth, cm	Two replications			Four replications		
	Arithmetic mean (M)	Mean error (M)	Index of accuracy (t%)	Arithmetic mean (M)	Mean error (M)	Index of accuracy (t%)
0—10	23.2	±0.70	3.02	24.5	±0.81	3.30
10—20	24.9	±0.50	2.01	25.5	±0.42	1.65
20—30	23.9	±0.20	0.84	24.2	±0.19	0.78
30—40	22.5	±0.20	0.90	22.8	±0.31	1.36
40—50	21.3	±0.80	3.76	21.6	±0.38	1.76
50—60	19.8	±0.40	2.02	20.5	±0.41	2.00
60—70	17.4	±0.40	2.30	17.9	±0.34	1.90
70—80	14.7	±0.30	2.04	15.5	±0.55	3.55
80—90	14.3	±0.30	2.10	14.7	±0.31	2.10
90—100	13.7	±0.60	4.40	13.8	±0.26	1.88
0—100	19.6	±0.44	2.25	20.1	±0.40	2.03

lower-lying horizons in its high moisture supply. It is the horizon of intensive circulation of moisture. A large proportion of the roots is concentrated in the humus horizon as well as the main concentration of micro-organisms. It is primarily from this horizon that the plant takes water and nutrients. We also took into consideration the role of the soil parent material (150-300 cm) in the moisture circulation of the entire three-meter profile.

The supply of available moisture in the soil was determined from the difference between the total moisture content and the unavailable portion. The latter was taken as the maximum hygroscopicity (as defined by Nikolayev). For the layers 0-20, 0-70, 0-150 and 150-300 cm it amounts to the following percentages: under perennial grasses on once- and twice-plowed land, 12.0%—11.8%—11.5%—9.7%, respectively; in black fallow, to 10.8%—10.3%—9.7%—9.3%; and under winter wheat on black fallow, to 11.2%—10.9%—10.7%—9.6%. For the same layers, the bulk density in the first case amounts to 1.25—1.28—1.32—1.50. These values are to be decreased by 0.04 for black fallow, and by 0.02 for winter wheat.

As may be seen from Table 2, four years out of five had a large supply in spring of available moisture in the 1.5 m layer under black fallow as compared with the average for five years. The exception was 1954, when the supply of available moisture was 57.6 mm less than the average, a condition attributable to unfavorable weather conditions. In the autumn-winter period preceding the spring of 1954, there was 1.5-2.4 times less precipitation as compared to the other years. This small amount of precipitation was used by the soil less productively. The winter was cold, with air temperatures 15°to 17° C, while on individual days it reached -27° to -33° C. Spring thaw was slow and the meltwater (in part) ran off on the surface of the as yet unthawed soil. The larger supply of soil moisture in the spring of 1952 may be explained by the better use by the soil of the precipitation of the autumn-winter and early spring periods, although 54-112 mm less fell than in the other years except 1954. The better utilization of the precipitation was allowed by the warm winter — with a comparatively uniform distribution of thaws over the period. The spring supply of available moisture in the parent materials in some years shows little deviation from the mean for the five years. The exception is 1954, when the spring supply of moisture was 12.8 mm more than the average, as a result of the effect of residual moisture from 1953.

The precipitation during the growing season does not compensate for evaporation losses of soil moisture. During the growing season one-third to one-fourth of the available moisture and the precipitation falling during this period are unproductively lost by the soil. The greatest amount of moisture was expended by the soil in 1951 and (especially) in 1952. The average daily loss for the growing season (including precipitation) was 2.2-2.5 mm. These two years were both characterized by a larger supply of moisture in the soil at the beginning of the growing season and by heavier precipitation during the season than the other years. The wettest soil will obviously lose more moisture to evaporation. This is confirmed by the data

Table 2

Available soil moisture to plants and its utilization during the growing period in black fallow, mm, 1951-1955

Year of observation	Precip. during preceding aut. - winter period, Oct. 1-Mar. 1	Precip. during growing season, April 12 - Sept. 14	April 12				July 12					Sept. 14				
			Layers, cm				Precipitation in mm between observations	Layers, cm				Precipitation in mm between observations	Layer, cm			
			0–20	0–70	0–150	150–300		0–20	0–70	0–150	150–300		0–20	0–70	0–150	150–300
1951	288	252	43.1	143.2	263.0	—	114	36.9	114.6	184.3	—	137	31.7	107.6	170.9	—
1952	178	319	46.3	158.8	270.7	162.1	223	45.8	147.6	266.9	206.5	94	25.3	85.1	199.7	137.6
1953	232	190	46.3	145.0	257.3	151.0	106	35.7	117.2	230.4	144.3	84	33.5	110.2	213.1	222
1954	120	245	39.1	125.0	190.0	175.4	190	32.7	112.8	172.8	104.3	55	29.3	105.0	168.9	124.3
1955	290	156	30.8	125.9	257.0	162.1	55	33.7	118.0	245.8	199.8	100	35.2	126.0	242.0	—
	Average		41.1	139.6	247.6	162.6	—	37.0	122.0	220.0	164.0	—	31.0	107.0	199.0	161

Table 3

Available soil moisture under winter wheat on black fallow and its utilization during growing period, mm, 1951-1955

Year of observation	Precip. during preceding aut. - winter period, Oct. 1-Mar. 1	Precip. during growing season Apr. 12-Sept. 14	April 12				July 12					Sept. 14				
			Layers, cm				Precip. in mm between observ.	Layers, cm				Precip. in mm between observ.	Layers, cm			
			0–20	0–70	0–150	150–300		0–20	0–70	0–150	150–300		0–20	0–70	0–150	150–300
1951	288	252	44.4	144.0	239.6	—	114	2.2	23.1	65.3	—	138	4.2	7.1	17.8	—
1952	178	319	55.5	168.0	293.0	200.8	223	40.9	122.7	144.5	84.9	117	15.1	68.5	91.1	80.7
1953	232	190	40.7	132.5	233.6	165.6	106	19.1	52.7	99.0	169.7	100	13.4	38.2	79.2	109.7
1954	120	245	41.2	142.2	237.6	93.2	190	1.7	18.7	53.5	173.9	55	2.0	27.6	75.2	138.7
1955	290	156	52.8	169.8	322.7	—	55	19.3	47.1	85.1	—	100	30.3	98.7	144.5	—
	Average	—	47.0	151.3	265.3	153.2	—	16.6	52.8	89.5	142.8	—	13.0	48.0	81.6	109.7

for 1953, 1954, and 1955, when the daily moisture losses averaged 1.5, 1.7, and 1.1 mm, respectively. In the literature opinions are divided on this point. According to Lebedev (4) the moisture content of a soil does not affect the evaporation energy of the same soil. Subsequent study of the point in question by a number of investigators (1, 3, 5, 6, 8) showed that there is a relation between the rate of evaporation from the soil and its wetness. Parkhomenko (7) showed by special experiments that there is a direct relation between soil moisture and the evaporation energy of the same soil. According to his data, evaporation will be greatest when the soil moisture is approximately at field capacity (but does not exceed it).

Under our conditions the loss of soil moisture in black fallow is most sharply manifested when its moisture content is not less than 25% (of dry weight). When this drops to 22%, the moisture loss drops relatively abruptly, and at 20%-19% the moisture level in the humus horizon stabilizes somewhat. But in the hot, dry season the moisture loss reaches lower values, stabilizing at 17%-16% (where the molecular capacity is 14%-15%). At 150-300 cm soil depth, moisture loss is most rapid at 16% or above; it becomes comparatively stable at 14% (with a maximum molecular capacity of 14%-15%).

As may be seen from Table 3, the greatest moisture loss under winter wheat on black fallow occurred at the beginning of the growing period in 1952 and 1955, which, as we remarked previously, is attributable to the favorable weather conditions of the preceding spring. A reduction in available moisture was noticed in the months that followed, being particularly marked at 120-150 cm depth when the grain was developing. The sharpest reduction in available moisture and unproductive losses were observed in 1951 and 1954. Toward the end of the growing period, on September 14, the supply of available moisture in the soil dropped, as compared to the spring of 1951, by 92%, in 1954, by 68%; in 1952, 1953, and 1955, by 69%, 66%, and 55% respectively. The mean daily loss for the growing period (from August 12 to September 14) came to 3.05 mm in 1951, 3.35 mm in 1952, 2.3 mm in 1953, 2.6 mm in 1954 and to 2.2 mm in 1955. The consumption of available moisture (plus precipitation from April 12 to harvest) per centner of grain was, in 1951, 19.2 mm with a harvest of 15 cntr/ha; in 1952, 11.7 mm with a harvest of 30 cntr/ha; in 1953, 10.9 mm with a harvest of 20.5 cntr/ha; in 1954, 17.6 mm with a harvest of 19 cntr/ha; and in 1955, 9 mm with a harvest of 34 cntr/ha.

The winter wheat harvested in 1955 grew on the supply of moisture in the soil, since from April to harvest precipitation was only 55 mm or 2-4 times less than in the preceding years. In 1952 the loss of soil moisture during the development of the winter-wheat harvest was compensated to some extent by precipitation in May and June (to the extent of about 200 mm, or 3.6 times more than in 1955). Thus the total consumption of moisture (soil plus precipitation) was 80 mm greater in 1952 than in 1955.

The presence of a supply of available moisture in the soil and its various horizons under this or that crop after harvest is an index of the suitability of this crop as a precursor for succeeding crops. According to the data of Table 3, the average supply of moisture over five years in the upper 20-cm layer of the soil is 16 mm after the harvest of winter wheat. On September 14 it dropped to 13 mm. The soil to a depth of 1.5 m contained 81.6 mm. The supply of available moisture was especially low after the harvest of winter wheat in 1951 and 1954 — in the upper (20-cm) layer, 2.2 and 1.7 mm, respectively; in the upper 1.5 m, 65.3 and 53.5 mm. On September 14, 1951, the supply of available moisture in the upper 1.5 m dropped to 17.8 mm.

As may be seen from Table 4, the supply of available moisture under perennial herbage was considerably less in 1950 than in 1951-1952. This was a dry year. During the autumn-winter period preceding the spring of 1950, precipitation was 125 mm, or 163 mm less than in 1951. The greatest supply of available moisture throughout the whole growing period was noted in 1952. This year was the most favorable as regards both the amount and distribution of precipitation. The soil moisture content under the individual forage crops were unequal. Moisture was higher in the first two meters of soil under alfalfa and on alfalfa-wheatgrass mixture than under wheatgrass of the same age (third year). Here the individual characteristics of these crops were manifested. Alfalfa has a well-developed root system reaching deep into the soil, along which precipitation moisture penetrates to a great depth, and the soil is more fully utilized than under wheatgrass. The branching root system of wheatgrass develops mainly in the upper layers of the soil. These characteristics also affected the nature of the changes in the supply of soil moisture in the succeeding months of the growing period.

Alfalfa uses the moisture from the deeper layers, so that during the growing period of 1951-1952 the supply of moisture in the second and third meters was less under alfalfa, especially as compared with wheatgrass. Wheatgrass consumes moisture principally from the first meter of the soil. In September 1952 the whole supply of available moisture in the upper (20-cm) layer of the soil under alfalfa and the alfalfa-wheatgrass mixture was used up. An abrupt drop in moisture content occurred at this time, over the whole first meter of soil. In this case the moisture was used for the growth of the plants after the hay cutting. Good

Table 4

Available soil moisture under perennial forage crops and its utilization during the growing period, mm, 1950-1952

Crop	Prcip. during preced. per. Sept. th. Mar.	April				May			June			July				September			
		Layers, cm																	
		0–20	0–100	100–200	200–300	0–20	0–100	100–200	0–20	0–100	100–200	0–20	0–100	100–200	200–300	0–20	0–100	100–200	200–300
1950																			
Alfalfa and wheat-grass, 3rd year	125	20.5	112.0	Not det'd.		12.0	59.5	Not det'd.	3.5	33.2	Not det'd.	3.3	26.8	Not det'd.		4.0	35.2	Not det'd.	
Precipitation in mm between observ.	—	—	—	—		—	2	—	—	16	—	—	44	"		—	56	—	
1951																			
Alfalfa	—	42.3	161.3	23.8	—	27.3	99.8	Not det'd.	19.5	62.7	—	4.5	35.8	23.8	Not det'd.	4.5	7.7	15.8	Not det'd.
Alfalfa and wheat-grass, 3rd year	288	37.0	139.5	22.4	—	27.5	121.6	"	6.5	30.7	—	9.0	16.6	13.2	"	4.8	12.8	10.6	"
Wheat-grass	—	25.3	89.6	2.6	—	7.8	46.1	"	2.8	29.4	—	0.0	9.0	36.9	"	1.5	15.4	22.4	"
Average	—	34.9	130.1	16.3	—	20.9	89.2	"	9.6	40.9	—	4.5	20.5	24.5	"	3.6	12.0	16.3	"
Precipitation in mm between observ.	—	—	—	—	–	—	36	—	—	49	–	—	30	—	—	—	137	—	—
1952																			
Alfalfa	—	40.8	193.3	64.6	44.4	Not det'd.						24.3	94.7	26.4	47.4	0.0	30.7	21.1	50.3
Alfalfa and wheat-grass, 3rd year	173	48.0	203.5	64.7	60.7	"						20.5	81.9	33.0	54.8	0.0	14.1	9.2	41.4
Wheat-grass	—	38.8	183.0	64.7	90.3	"						15.8	62.7	27.7	78.4	23.3	48.6	19.8	53.3
Average	—	42.5	193.2	64.7	65.1	"						20.2	79.7	29.1	60.2	7.8	31.1	16.7	48.0
Precipitation in mm between observ.	—	—	—	—	—			—	—			—	202	—	—	—	117	—	—

growth of the forage was permitted by the summer precipitation (319 mm). In 1951, the average daily moisture consumption (from soil plus precipitation) for the growing period (April 12 to September 14) amounted to: under alfalfa, 2.8 mm; under an alfalfa-wheatgrass mixture, 2 mm; and under wheatgrass, 2 mm. In 1952 it amounted to 3.4 mm, 3.6 mm, and 2.8 mm, respectively.

In 1952 the perennial grasses used up more moisture. It yielded in that year a higher hay harvest than in 1951. In 1951 the alfalfa hay harvest was 27.6 cntr/ha; that of mixed alfalfa-wheatgrass, 30.8 cntr/ha; and that of wheatgrass, 24.4 cntr/ha. Moisture consumption (soil moisture plus precipitation during the period to the hay harvest) was 8.8, 7.6, and 6.6 mm per centner of hay, respectively. In 1952 the harvest of alfalfa hay reached 52.3 cntr/ha; that of the alfalfa-wheatgrass mixture, 56.4 cntr/ha; and that of wheatgrass, 27.5 cntr/ha. Consumption of moisture (from soil and precipitation) per centner of hay amounted to 6.2, 6.0, and 10.3 mm, respectively.

If we compare the mean daily consumption of moisture in the growing period (April 12 to September 14) by winter wheat on black fallow and by the perennial forage crops, it turns out that it is practically the same in either case. In the relatively dry year of 1951, the mean daily moisture consumption under perennial forage crops was somewhat less than under winter wheat.

The density of the forage crops had its effect on the changes in the moisture content of the soil. A dense (887-1075 shoots per m^2) cover is more economical and uses the soil moisture more productively than a sparse cover (407-605 shoots per m^2). This was especially apparent in the dry year of 1951. In May 1950 the soil moisture content under thick grass was 1.5%-3% lower than under a cover half as dense. In the following months the soil moisture content under dense and sparse grass was equalized, but from June 29 to September (until the hay harvest) five plots out of seven showed higher soil moisture content under the dense crop. A difference in soil moisture content between the dense and the sparse crops in three cases out of five is very probably: the coefficient of reliability was more than 3; in two cases it was 1.4-2.2.

At the same time, observations were made of the soil temperature (in the first 40 cm) and of atmospheric humidity in the dense and sparse forage crops, and in black fallow, for purposes of comparison. Under the dense forage crops the soil temperature was 7° C lower than under the sparse, and 14° C lower than in the black fallow. These differences were observed to a depth of 40 cm but were more sharply pronounced in the upper layers of the soil. The relative humidity of the air in the dense forage crop was 5%-18% higher than for the sparse crops, and 14%-30% higher than for the black fallow. The differences in soil temperature and relative humidity of air in the plants is particularly pronounced in clear sunny weather, at 1:00 pm in the hot days of summer.

As may be seen from Table 5, the supply of available soil moisture was less during the growing period under perennial grasses, and it was lower at 150-300 cm depth. Here we see clearly the ability of perennial forage crops, especially alfalfa, to utilize moisture from the deepest levels, which is not used by annual crops (grain), being for them a sort of "dead capital."

The moisture lost from the soil and parent material during the growth of perennial forage crops is almost completely restored after the first and second plowing of fields in these crops (to the level in black fallow). The effective renewal of the supply of moisture in the second and third plantings after perennial forage crops is ensured by the fuller soil utilization of atmospheric precipitation, owing to the improved physical properties and structure of the soil. The legume-grass forage mixture in its third year produced, even in the first sequence of crop rotation, an increase in the number of particles >0.25 mm in diameter as compared to an old plot of winter wheat (by 17%-21%).

Perennial forage crops make a more productive use of soil moisture than annual crops (grain). In 1952, according to our observations winter wheat (on black fallow) on June 14 produced a top yield of 65.5 cntr and a root yield to 40 cm deep of 46.73 cntr, or a total air-dry weight of 112 cntr/ha. By this time 95.64 mm of moisture had been consumed in the upper 2 m of the soil, or 60.6% of the spring supply of available moisture. On this same date an alfalfa-wheatgrass mixture in its third year had produced a top yield of 42 cntr and a root yield in upper 40 cm of 166 cntr, or total air-dry weight of 208 cntr/ha. During this time the mixed forage consumed 77.44 mm of moisture from the upper 2 m of soil, or 57% of the spring supply of available moisture. Thus the alfalfa-wheatgrass mixture in its third year produced nearly twice as large a top and underground yield, and at the same time used 3% less moisture than did winter wheat.

For an objective evaluation of moisture consumption by perennial forage crops, it is necessary to take into account the amount used to produce not only the tops (hay), but also the underground mass (roots). The latter is an effective means of enhancing fertility and maintaining it as high a level as possible in field-crop rotatio

The depth of spring wetting and the degree o drying of the soil under individual crops vary.

Table 5

Comparison of changes in the available moisture content in soil under individual crops of a field-crop and forage-crop rotation during growing season, mm. Five-year averages (1951-1955)

Crop	On April 12				On July 12				On September 14			
	Layers, cm											
	Plow layer 0-20	Humus horizon 0-70	Illuvial horizon 70-150	Parent material 150-300	Plow layer 0-20	Humus horizon 0-70	Illuvial horizon 70-150	Parent material 150-300	Plow layer 0-20	Humus horizon 0-70	Illuvial horizon 70-150	Parent material 150-300
Black fallow	41.1	139.6	108.0	162.6	37.0	122.0	98.0	164.0	31.0	107.0	92.0	161.0
Winter wheat on black fallow	47.0	151.3	114.0	153.2	16.6	52.8	36.7	142.8	13.0	48.0	33.6	109.7
3-year old perennial grass	38.8	127.6	74.4	87.8	11.0	39.4	26.4	72.0	3.3	17.9	15.8	63.0
First crop after perennial grass (spring wheat)	43.9	123.6	76.4	108.0	5.3	25.1	20.1	112.5	10.3	29.6	23.9	164.3
Second planting after perennial grass (spring wheat)	40.5	136.	70.8	—	2.8	21.5	34.8	—	11.3	36.7	32.7	—

Table 6

Comparison of consumption of available soil moisture under individual crops of a field-crop and forage-crop rotation during growing season, mm. Five-year averages (1951-1955)

Crop	Available moisture content, April 12				Consumption of available moisture							
					April 12 to July 12				July 12 to Sept. 14			
	Layers, cm											
	Plow layer 0-20	Humus horizon 0-70	Illuvial horizon 70-150	Parent material 150-300	Plow layer 0-20	Humus horizon 0-70	Illuvial horizon 70-150	Parent material 150-300	Plow layer 0-20	Humus horizon 0-70	Illuvial horizon 70-150	Parent material 150-300
Black fallow	41,1	139,6	108,0	162,6	4,1	17,6	10,0	+ 1,6	6,0	15,0	6,0	3,0
Winter wheat on black fallow	47,0	151,3	114,0	153,2	30,4	98,5	77,3	10,4	3,6	4,0	3,1	33,1
3-year old perennial grass[a]	38,8	127,6	74,4	87,8	28,8	88,2	48,0	15,8	7,7	21,5	10,6	9,0
First crop after perennial grass (spring wheat)	43,9	123,6	76,4	108	38,6	98,5	56,3	+ 4,5	+5,0	+4,5	+3,8	+51,8
Second plowing after perennial grass (spring wheat)	40,5	136,2	70,8	—	37,7	114,7	36,0	—	26,4	+0,7	0,0	—

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[a] Alfalfa-wheatgrass mixture and its components.

The average depth of wetting (over the five years) in black fallow was 140 cm, with fluctuations in this or that year of 90-210 cm; and under winter wheat on black fallow, 217 cm, with fluctuations of 130-300 cm. Wetting of the soil under the alfalfa-wheatgrass mixture in its third year reached 110-140 cm; under alfalfa at the same age, 110-150 cm; and under wheatgrass, 70-100 cm. After plowing of alfalfa, it reached 200 cm; of an alfalfa-wheatgrass mixture, 130 cm; and of wheatgrass, 90 cm. After second plowing of grass sod, it reached 100-120 cm.

Soil drying in black fallow, as shown in Table 6, is more marked in the upper 70-cm of the soil; at 70-150 cm the drying is less. Under winter wheat on black fallow, drying is observed to 1.5 m but is more marked in the upper 70 cm. After the harvest of winter wheat, some reduction in moisture was also observed at 150-300 cm. The same sort of drying was observed under spring wheat sown on once- and twice-plowed forage-crop land, with this difference — after the harvest of the spring wheat the supply of moisture over the entire profile was noticeably higher. Under perennial forage crops (alfalfa and the alfalfa-wheatgrass mixture), drying was more noticeable in the second and third meters of soil, but under wheatgrass, mainly in the first meter.

CONCLUSIONS

1. In a field-crop and forage-crop rotation, black fallow provides the greatest supply of moisture in the upper 3 m of soil throughout the whole growing period. In black fallow, the precipitation of the spring-summer period is more fully utilized, but they do not compensate the moisture losses over the whole growing period. The consumption of available moisture constitutes 19.6%-35% of the spring supply.

2. Soil under winter wheat on black fallow makes good use of the precipitation of the autumn-winter period (during the year the winter crop is sown) and of the spring meltwater of the succeeding year. The consumption of available soil moisture during the growing period amounts to 69.2%-92% of the spring supply.

3. The consumption of available moisture by perennial forage crops during the growing period amounts to 82.4%-90.4% of the spring supply. Forage crops use moisture more productively per unit of dry weight. For an objective evaluation of moisture consumption by perennial forage crops, it is necessary to take into account the amount used not only to produce top mass (hay), but also the root mass.

4. The moisture used up by perennial grasses is restored almost wholly in the first and second plowing after the perennial forage (spring wheat sown). The effective renewal of moisture in the first 3 m of soil after the first and second plowing is secured by the fuller utilization of the precipitation of the autumn-winter and spring-summer periods, by reason of the improvement of the physical properties and structure of the soil during the growth of perennial forage crops.

Received November 18, 1958

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ENSIOMETRIC AND ELECTROMETRIC METHODS OF MEASURING SOIL MOISTURE

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The acute need for large-scale observaions of the water regime of soils for various gricultural, forestry, and hydro-technical urposes has set before soil physics the urgent ask of developing inexpensive, rapid, and accurate methods of determining soil moisture nder field and laboratory conditions. The ethod of determining moisture in samples withrawn from soil is complicated, however; morever, it breaks up the soil cover. Thus, at presnt, the most promising methods are those which ermit continuous determinations of soil moisure to be made in situ.

The majority of the proposed methods are ased on the fact that there is a functional deendence between the moisture of the soil and s physical properties, namely: the heat capaity and heat conductivity, the electrical conuctivity and dielectric permeability (1, 4, 6, 2), and the capillary forces. It is thus possile to determine the soil moisture by measurng the magnitude of one of these properties ith instruments which are permanently kept the soil.

The study of the capillary forces which deelop in the soil has proved particularly fruitul. Capillary forces can be characterized by e magnitude of the negative (capillary) presure (H), which denotes the amount of work one in relation to a volume unit of liquid. The imension of the capillary negative pressure is xpressed as follows: (units of work/units of olume) = (units of pressure). By using this haracteristic it is possible to establish a ingle pressure scale for all conditions of soil oisture. If the soil has a water-table, then the upper surface of the water table the moisure is subject to zero pressure. Below this evel, in the saturated zone, the pressure is ositive; above, in the unsaturated zone, the ressure is negative. Various units are used measure negative pressure: atmospheres, ars, millimeters of mercury, centimeters of ater, and, lastly, pF, which is equal to the garithm of the negative pressure expressed in entimeters of water with the opposite sign.

Existing methods of measuring the negative pressure of soil moisture are either direct or indirect. One of the direct methods consists in bringing the soil into contact with a porous-walled cell filled with water. If the soil is not saturated with moisture , the water from the cell moves into the soil until the negative pressure of the soil moisture equals the negative moisture pressure inside the cell. It is this principle that forms the basis of the "tensiometer" for measuring negative pressure in the field (3, 13, 14, 15). The tensiometric method, however, is effective only for negative pressures greater than one atmosphere, since at lower pressures the water vaporizes ("cold boiling").

At negative pressures of less than one atmosphere it is necessary to resort to indirect methods of measurement. Currently the most widely used method is that of calibrated proous bodies — blocks of gypsum, glass or nylon fiber, cement, etc. The pore space of the block has a fixed configuration and in some cases (gypsum) the blocks are buffered against salt solutions (2, 7, 8, 9, 10, 11, 15, 16). The blocks are in constant capillary contact with the soil, and consequently the negative moisture pressure in the soil-block system tends to equalize. For a rough estimate of the magnitude of negative pressure in the soil, it is sufficient to measure it in the block. This in turn is a function of the electrical properties of the block. There is thus the following functional sequence: soil moisture — negative pressure of the soil moisture — negative pressure of the moisture in the block — electrical conductivity (dielectric permeability) of the block. For practical purposes it is often sufficient to establish an empirical connection between the two end members of the series, i. e., the moisture content of the soil and the electrical conductivity of the block. This method is preferable to the measurement of electrical properties of the soil itself, since this is technically very difficult (1, 4).

The importance of studies of negative pressure is not restricted merely to soil-moisture determinations. There has long been an acute need for an independent thorough study of the energy state of soil moisture; for on it depend such important properties of the soil as the capacity to absorb, retain, and transfer moisture as well as to supply it to plants. The use of single energy characteristics in the study of the water regime of the soils and plants, by excluding to a large extent the effect of differences in soil texture and constitution, makes it possible to draw more general conclusions.

This study was devoted to perfecting the design of instruments for the measurement of negative moisture pressure and moisture content in the soil and to developing the best methods of using and calibrating the instruments.

The work was carried out on light-chestnut slightly solonetzic medium clay loams and on ordinary fine clay loam chernozems. Some physical characteristics of these soils are presented in Table 1. The first section of this paper deals with the results of a study of the tensiometric method; the second, with a study of the block method.

Table 1

Physical properties of medium clay loam light-chestnut soil and fine clay loam chernozem

Soils	Horizon and depth, cm	Maximum hygroscopic moisture,%	Bulk density, gms/cc	Porosity, %
Light-chestnut	A 10	Not det'd.	1.28	52
	B 40	"	1.36	50
	C 70	"	1.48	47
Chernozem	A 20	10.8	1.15	56
	A 40	11.8	1.20	54
	B 60	10.0	1.30	51
	BC 90	9.6	1.38	49
	C 120	9.0	1.43	47

Tensiometric Method

GIKI bacterial filters, mark F-5, type 5-a were used as tensiometric cells. The filter was connected to a manometer by a rubber vacuum tube, glass and brass tubes. The mercury manometer consisted of a thick-walled glass capillary tube with an internal diameter of 1.5 mm. Each limb of the manometer was 75 cm long, and at the top end of one was a valve through which air could be evacuated while the instrument was being filled with water.

For measurements at deep levels (to 1.5 m) the filter was placed into a hole made with a drive pipe. This was done in such a way that the area of contact between the filter and the soil was not less than 25 cm^2. Since capillary equilibrium is established rather slowly (in not less than 24 hours even at a minimum moisture capacity) the tensiometers were set up within the measurable time throughout the experiment.

The tensiometers were first calibrated under field conditions. Determinations were made on a bare 3-m^2 plot of light-chestnut soil and on three 8 m^2 chernozem plots: 1) without vegetation 2) with four-year-old ash seedlings, and 3) with four-year-old oak seedlings. The plots were bordered and irrigated until the moisture at a depth of 2 m was at field capacity.

Moisture determinations were made at intervals of 1%-2% decrease. All weight and tensiometric determinations were replicated twice. The calibration curve was plotted in 3 stages: 1) the curve of negative pressure vs. time, 2) the curve of soil moisture vs. time, and 3) the curve representing the dependence of negative pressure on soil moisture, by plotting points corresponding to different moments of time.

The results presented in Figure 1 and 2 show that the relationship of negative moisture pressure on the moisture content in the various soil horizons is represented by a set of hyperbolic curves. In an analytic form they are expressed by power-function equations (Table 2). The porous filters which we used provided reliable data up to a negative pressure of 400 mm of mercury; beyond this point air began to seep through the walls of the filter and this upset the equilibrium of the soil-tensiometer system. As regards the accuracy of the tensiometric soil-moisture determinations, generalized calculations have shown that the mean square deviation of the individual measurements (t) was 0.4% of the weight of the dry soil, but when moisture was measured by the drilling and drying method, (t) was 0.8%.

Since field calibration is time consuming (from one to two months), we tried to find other methods of calibration under laboratory conditions. The first series of tests was carried out with disturbed samples from different genetic horizons of light-chestnut soils. The samples were passed through a sieve with 3 mm openings and poured into unglazed clay pots, where they were moistened and tensiometers were placed. The soil water evaporated through the porous pot walls. The calibration results differed greatly from those obtained under field conditions, especially for horizons A and B (Fig. 1). For horizon C the results were closer, but even here, at one and

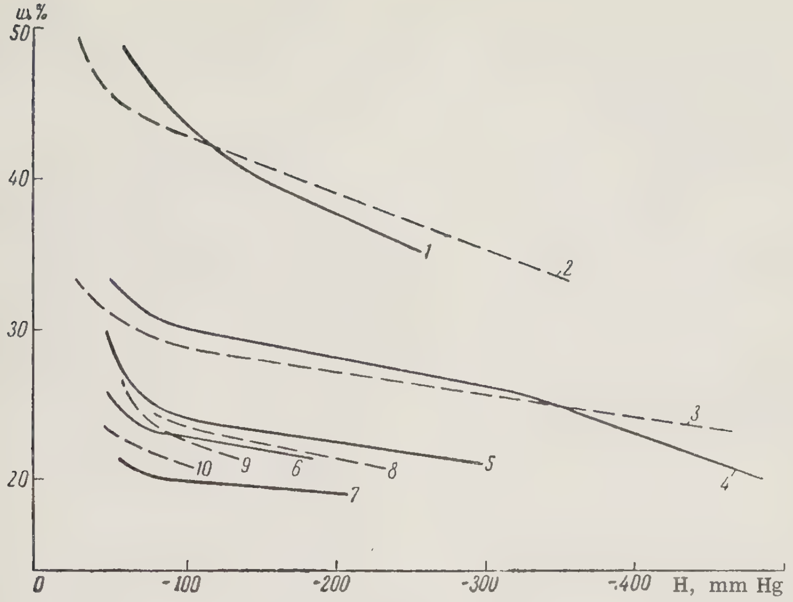

Fig. 1. - Relationship of the negative moisture pressure (H) and moisture (w) for a light-chestnut medium clay loam.
For bulk samples: 1 - A-horizon (10-14 cm); 2 - B (14-27); 3 - C (48-80); 4 - A disturbed. For the monolith; 5 - A (10 cm); 6 - B (40); 7 - C (70); For field experiments; 8 - A (10 cm); 9 - B (40); 10 - C (70).

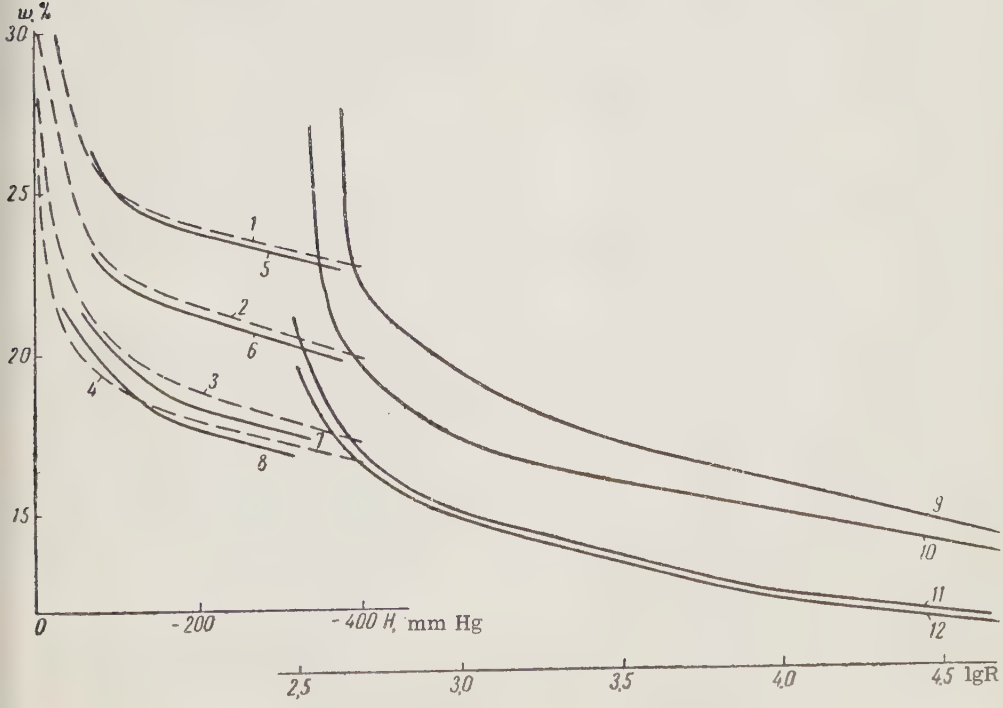

Fig. 2. - Relationship of negative moisture pressure (H) and electric resistance of blocks (R) on the moisture (w) for fine clay loam chernozem.
For samples with natural structure: 1 - horizon A (20 cm); 2 - A (40); 3 - BC (90); 4 - C (120); For field tests; 5 - A (20 cm); 6 - A (40); 7 - BC (90); 8 - C (120); log R = f (w) for field tests; 9 - A (20 cm); 10 - A (40); 11 - BC (90); 12 - C (120).

Table 2

Relation between soil moisture and negative pressure for an ordinary clay loam chernozem

Horizon and depth, cm	Formula
A 20	$w = 38.9 \cdot \lvert H \rvert^{-0.10}$
B 50	$w = 36.0 \cdot \lvert H \rvert^{-0.09}$
BC 90	$w = 37.2 \cdot \lvert H \rvert^{-0.12}$
C 120	$w = 35.3 \cdot \lvert H \rvert^{-0.11}$

Note: w = soil moisture as a percentage of the weight of dry soil H = negative pressure, mm of mercury.

the same negative pressure, soil moisture as determined under laboratory conditions was 1.5 times higher. This was due to the fact that the wetting of the disturbed samples did not remove the lumps formed in the course of extraction, pulverization, and sifting of the samples; these bore no relation to the soil in its natural state. By crushing the sample in a moist state it was possible to remove some of these lumps and so to bring about closer agreement with the results obtained under field conditions, but even so the results cannot be regarded as satisfactory.

The second series of tests was carried out with a monolith of light-chestnut soil 1 m high and (15 x 15) cm^2 in cross section. It was isolated from the side walls with sealing wax and moistened. The soil was dried from the top under conditions which approximated the natural. Tensiometric tubes for recording the negative pressure were inserted at different depths into the side walls of the monolith. Samples for soil moisture determination were taken from the monolith with a borer through paraffin-filled openings in the sealing-wax insulating cover. The results approximated those obtained under field conditions (Fig. 1). However, since tests with large monoliths are complicated and awkward, in the third series of tests we used small-scale samples, in which the natural soil structure was retained. The samples were obtained by pressing into the moist soil a small aluminium beaker 4 cm high and 5 cm in diameter. Under laboratory conditions the samples were placed on the flat surface of cone-shaped porous ceramic filters which were connected with a pump. The filters were filled with water and the pressure in them was lowered in steps. The pressure was decreased only when water ceased to seep out of the soil at a given pressure. The amount of seepage was determined by weighing the samples. To prevent evaporation, the sample was covered with a glass cap. The results of this series of tests closely approximated those obtained under field conditions (Fig. 2). The simplicity and accuracy of this method make it the most promising.

Gypsum Block Method

Bouyoucos-type (7) gypsum blocks were tested in fine clay loam ordinary chernozems. The blocks, of our own make (Fig. 3a), consisted of gypsum cylinders (1) 7 cm long and 5 cm in diameter, into which were inserted two blades of stainless steel (2), which served as electrodes. Through the axis of the cylinder ran a canal (3) 16 mm in diameter. Several blocks were mounted on a brass tube 15 mm in diameter through which ran leads connecting the electrodes to the measuring apparatus. The spaces between the blocks were filled with circular gypsum interlayers. This column, of the required height, was lowered into a hole bored in the soil. The top of the hole was then covered with earth, which was firmly compacted. Capillary contact was effected by watering the soil, causing it to swell and press against the blocks.

The blocks were made in separable moulds (Fig. 3b), consisting basically of a metal cylinder (1) mounted on a rubber slab (2) and lined inside with rubber padding (3). A piece of vacuum tubing encased the metal rod (4) and was attached at the bottom to the center of the rubber slab and at the top to the cover (5). The electrodes were held by screws (6) in the cover

To mould the blocks, alabaster was passed through a 0.5 mm opening sieve thoroughly mixed for 40 sec with distilled water in a ratio of 1:0.6; the suspension was then poured into the mould. Once it had begun to set in the required shape, the mould was taken apart and the block dried in air.

The relationship between the negative moisture pressure in the block and its electrical conductivity was studied under laboratory conditions in 80 blocks. For this purpose bloc saturated with water were gradually dried in cloth-covered vessels, and from time to time measurements were made of the electrical resistance of the blocks and the temperature depression in them, which is related to the negative moisture pressure by the relationship

$$1g\,[H] = +4.1 + 1g\,\Delta t,$$

where [H] is the negative pressure in cm of water, and Δt is the freezing-point depression of water in °C.

The electrical resistance was determined with ac and a Wheatstone bridge. To amplify the current load to the measuring instrument a two-stage amplifier connected to the line

rrent or to batteries was used. The freezing
int was measured with Beckmann thermomet-
s (metastatic), permitting readings to be
ade with an accuracy of 0.02°C. To achieve
tter thermal contact between the bulb of the
ermometer and the block, the axial hole was
igged at the bottom with a cork and filled
th mercury; the bulb of the thermometer was
en immersed in the mercury. Freezing was
fected in a metal beaker placed in a mixture
ice and table salt. The temperature of the
xture was 3-5°C below the required freezing
nperature. Before being subjected to freez-
g the blocks were first cooled to +1°C. The
eezing temperature was determined from the
splaced segment of the cooling curve for the
ock (we did not encounter pronounced super-
oling as with liquids). The results of the
peated freezing of blocks after thawing
owed a remarkable agreement with the orig-
al findings; the deviation did not exceed 10%
the measured value. The calibration re-
lts demonstrated that the relationship be-
een the freezing-point depression and the
ectrical (ohm resistance in the negative-
essure interval -2 atm > H > -15 atm could
approximately expressed by the formula
R = 6H + 2.5, where R is the electrical re-
stance of the blocks.

The plotting of the calibration curves for
blocks from the field data was very similar
the procedure used in the tensiometric meth-
. The electrical resistance under field con-
ions was measured by a cable bridge of the
M" type, operating with alternating current
in the Wheatstone bridge. As with tensiometers, the relationship of the electrical resistance of the blocks to the soil moisture for the various horizons was represented by a set of identical parallel curves (Fig. 2).

As a result of the spread of the electric current beyond the limits of the block, the measurements gave us a value for the total electrical conductivity of the block and soil. Thus, at a negative pressure of 300 mm of mercury, an average of 25% of the current load to the electrodes passed through the soil (Table 3). As a result it was impossible, in a block of the design described, to determine the negative soil-moisture pressure without previous calibration, and then only on the basis of the results of laboratory calibrations. The employment of concentric electrodes helped to overcome this defect.

Statistical calculations by the generalized method established that the mean square deviation of the individual soil-moisture determinations by the block method for the whole test was equal to 0.5% of the weight of dry soil.

As will be observed from Figure 2, curves for the dependence of electrical resistance on soil moisture have a bend at a pressure of -300 mm of mercury. At larger pressures, individual measurements of moisture by the block method became less accurate. Thus it is preferable to determine soil moisture in the interval 0 > H > -300 mm Hg by the tensiometric method. By using the two methods jointly it is possible to carry out accurate and uninterrupted measurements over the whole range of soil

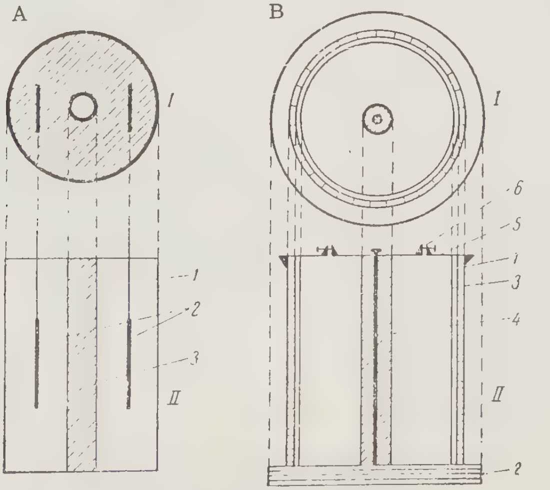

Fig. 3. - Gypsum block (A) and the mould for its preparation (B).

1 - transverse section; 2 - longitudinal section. (Explanation in the text).

Table 3

Spread of electric current beyond the limits of the gypsum block in ordinary fine clay loam chernozem when the negative pressure is -300 mm Hg

Horizon and depth, cm	Electrical conductivity			
	Total (block + soil), 1/ohm	Of the block, 1/ohm	Of the soil (by diffr.)	
			in 1/ohm	as % of the total
A 20	$215 \ 10^{-5}$	172 10	$43 \ 10^{-5}$	20
A 40	$230 \ 10^{-5}$	"	$58 \ 10^{-5}$	25
BC 90	$238 \ 10^{-5}$	"	$66 \ 10^{-5}$	28
C 120	$245 \ 10^{-5}$	"	$73 \ 10^{-5}$	30

Table 4

Tensiometric and gypsum-block results obtained at a moisture content corresponding to the hydrological soil constants of different horizons of an ordinary fine clay loam chernozem

Horizon and depth, cm	Minimum moisture capacity (mm)			Capillary discontinuous moisture (70% of mm)			Wilting moisture		
	% of		in mm Hg	% of		Log (ohm)	% of		Log (ohm)
	Weight	Vol.		Weight	Vol.		Weight	Vol.	
A 20	25.0	28.7	—100	17.5	20.1	3.35	15.8	18.1	4.05
B 40	23.0	27.6	—105	16.1	19.3	3.35	14.8	17.8	4.05
B 60	21.5	27.9	—100	15.2	19.7	3.30	13.2	17.2	4.10
BC 90	20.0	27.6	—100	14.0	19.3	3.30	12.0	16.5	4.15
C 120	19.5	27.9	— 80	13.7	19.6	3.35	11.8	16.9	4.17

moisture from saturation moisture capacity to wilting moisture.

At moisture values corresponding to the various soil-hydrological constants, the tensiometric and block readings showed good agreement for the different genetic horizons of the soils studied (Table 4). This proved once again that hydrological constants correspond to certain stable values of negative pressure (5). It is noteworthy that the variation in the values of the hydrological constants over the chernozem soil profile did not exceed 2% in terms of soil volume, and in the majority of cases was 0.4%-0.6%. This shows that it is a fairly uniform characteristic of all genetic horizons for the pore space to be filled with water at a moisture content equal to the minimum moisture capacity. The differences in the values of hydrological constants which appear when they are expressed in percentages of soil weight are due to the decrease of the bulk density of the soil in the surface horizons, which in turn, is due to the following two basic factors: 1) decrease in the density of the solid phase because of an increase in the content of organic matter, and 2) the formation of large pores, the effective diameter of which exceeds 0.05 mm.

Conclusions

1) A study of the suitability of tensiometers and gypsum blocks for the accurate determination of moisture in clay loam light-chestnut and chernozem soils has demonstrated that, when tensiometers are used within a range of negative capillary pressure of soil moisture from -50 mm Hg $>$ H $>$ -300 mm Hg, and when gypsum blocks are used within the range -300

m Hg $>$ H $>$ -15 atm under fixed conditions, is possible to obtain continuous information n soil moisture which is more accurate than at obtained by boring and drying the samples emoved.

2) To calibrate instruments which work on e principle of capillary equilibrium, it is ssential under laboratory conditions to use oil samples with a natural (undisturbed) strucre.

3) The soil-hydrological constants of the arious genetic horizons of the soils studied ninimum moisture capacity, capillary disontinuous moisture, permanent wilting moisre) correspond to particular tensiometric nd gypsum-block readings. This proves the omogeneity of the soil profile as regards to ore space.

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REVIEWS

PROBLEM OF SURFACE INTERACTION OF A SOLID AND WATER

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I should like in this short review to make several comments on the article by I. A. Tyutyunov—"Interaction of the Mineral Part of Soil and Water," published in issue No. 2 of the Journal Pochvovedenyie for 1959.

The author rightly points out at the beginning of the article that, in order to explain the physical nature of the interaction of solid mineral particles and water, "we must find the explanation founded on certain conditions established in allied sciences," evidently, physics and chemistry of surface phenomena. However, this was not realized in the article. In reading this article, on the other hand, we can see the weakness in the author's presentation relative to present-day views on the adsorption and wetting phenomena which take place on the surface of a solid.

Tyutyunov begins his account of the wetting phenomenon by examining the thermodynamics of this process. At the same time he completely ignores the principal works on the thermodynamics of surface phenomena, where these problems have been discussed accurately and rigorously (4, 7, 8, and 9). This leads to thermodynamic errors. Thus, for example, on page 30 the specific surface energy of a solid was determined as the difference between the total internal energy of the solid-water system (v) and the sum of the internal energies of a solid (v_1) and of water (v_2) related to a unit surface S, that is,

$$\sigma = \frac{v - (v_1 + v_2)}{S} = \frac{v_S}{S} \qquad (1)$$

On the same page Tyutyunov also gives another definition: "σ—is the work of the formation of 1 cm² of surface." It is easy to see that owing to the confusion in basic thermodynamic concepts between the free and internal energy systems, both definitions indicate different values: in the first definition, $S\sigma$—is the value of the total internal energy of the surface, while in the second definition it is the free energy of the surface. Thus, in equation (1) we could properly understand the values of free energies by the values of v, v_1, and v_2. But even with such a correction the difference $v - (v_1 + v_2)$ does in no way determine the free surface energy of a solid, that is, the work of the formation of one square centimeter of surface in a vacuum but, instead, the work of wetting of a solid by a pure liquid, which is equal to the difference between the free surface energy of a solid at the boundary between the solid and the vacuum $S\sigma_1$ and the interfacial tension $S\sigma_{1-2}$ at the boundary between a solid and a liquid, that is,

$$A = S\,(\sigma_1 - \sigma_{1-2}). \qquad (2)$$

Accordingly, the heat of wetting, equal to the change in the total internal energy of the surface during wetting, as was already shown in 1920 by Harkins and Ewing (10), is determined by

$$Q = S\left(\sigma_1 - \sigma_{1-2} + T\frac{\partial(\sigma_1 - \sigma_{1-2})}{\partial T}\right). \qquad (3)$$

As numerous data shows, the work of wetting may differ from the heat of wetting by 40%-70% (8).

This inaccuracy in determing the energy of the surface leads the author of the article also to other erroneous conclusions. On page 31 the author defines the heat of wetting as "the residual heat of hydration of ions which form this surface." Apart from the unsubstantiated and simplified investigation of the wetting process, there also exists in this assumption a thermodynamic inaccuracy. Actually (8) the heat of wetting is equal to:

$$Q_{hw} = Q_a^S - X_2^S L_2 + S\left(\sigma_2 - \frac{Td\sigma_2}{dT}\right), \qquad (4)$$

where Q_a^S—is the integral heat of water vapor adsorption; X_2^S—is the value of saturated vapor adsorption; L_2—is the latent heat of evaporation of an adsorbent, and σ_2 its surface tension. The energy, which is liberated during interaction of water and surface centers of adsorpion is determined only by the first term of this equality—Q_a^s.

Then, Tyutyunov maintains (page 32) that 'the heat of wetting is in inverse ratio to tem- erature." As an analysis of the temperature relation of all terms included in equation (4) shows, the temperature coefficient of the heat of wetting is small (7, 8), and may slightly ncrease and decrease with change of tempera- ure. This was confirmed by direct experi- ments (6, 5) established for the purpose of verifying these considerations, but which con- irmation, it appears, is unknown to the author of the article.

Speaking of the change in surface energy vith temperature, Tyutyunov on page 32 writes hat "this is confirmed by experiments" and ntroduces by way of proof the fact of increase n adsorption with lowering of termperature. Ie writes that "as long as the surface energy ncreases with a lowering of temperature, the hickness of the water films around the mineral particles increases." But he forgets that ad- sorption is determined in the first place by an equilibrium pressure (2) which depends upon emperature. Therefore, the comparison, vhich he makes in Figure 2, of the isotherms of water-vapor adsorption on bentonite, meas- ured under various temperatures, is meaning- ess. Actually if we plot along the axes of the bscissas not the equilibrium pressures but rather the relative pressures (p/ps), as is lways done in measuring isotherms of adsorp- ion, it is easy to see that the adsorption iso- herms in Figure 2 differ very little within ndicated temperature ranges. The thickness of the adsorption film is determined in the first place by the relative pressure of the vapor. A umber of studies have shown (2) that the ad- sorption potential actually does not depend upon emperature.

The purpose of thermodynamic arguments by he author of the article is to provide explana- ions for such an important phenomenon in ature as moisture movement. It would seem ecessary to resolve this problem by beginning vith the existing basic physical determinations nd relations. However, they do not satisfy Tyutyunov, and, in place of the well-known concept of the chemical potential by Gibbs (4) $\mu = \frac{\partial F}{\partial n}$ (which is equally applicable to both olumetric and surface phases), he introduces new chemical potential $v = \frac{\delta F}{\delta S}$ which is simply he surface density of free energy when the ther parameters of the system are constant; fail to see why he calls this the chemical otential. The author considers the difference etween the chemical potentials which he has ntroduced as "a driving force which determines the direction and limit (extent) of the spatial movement of water." The cause of the difference in chemical potentials lies, according to his idea, in the temperature and pressure gradient. It has been shown previously that the work of wetting is not determined merely by the free surface energy of a solid but depends also upon interfacial tension σ_{1-2}. To construct a theory based on values (1) not determined directly from an experiment is impracticable.

Instead of a qualitative study of the movement process, its direction depending upon the parameters of the medium, Tyutyunov sets forth in his article a number of principles which have not been physically substantiated. Thus, for example (pages 33 and 34), he assumes the existence of active forces of attraction and repulsion among the particles of soil material (without explaining what forces). On page 34 we find a peremptory assertion that the capillary mechanism of the rise of water in the soil is incorrect (no explanation is given as to why), etc. On page 35 the author evidently does not agree with the concept of the surface phase introduced by Gibbs (4, 3), and, in place of one phase, introduces two phases—the boundary phase consisting of "single molecules of water, correspondingly oriented and compact" (condensed) (that is, evidently, a monolayer) and the pre-boundary phase (evidently, a multilayer). These innovations of Tyutyunov which have in no way been justified are set forth in very contradictory fashion. On the one hand, he points out that the boundary phase consists of oriented molecules of water, while on the other hand (in the next paragraph), he writes that the thickness of this monomolecular film is "tens of angstrom units," although the cross-section of a water molecule is about three angstroms; below he speaks of the thickening of this monomolecular film. The incompatibility of these three positions is obvious.

The problem of moisture movement is one of the basic problems in permafrost studies. To resolve it, we must undoubtedly draw on the present-day concepts of physics and chemistry on surface phenomena, in particular, the experimental data on the mechanism of water adsorption, state of the substance in the adsorbed phase, etc. The author substitutes this natural means of analysis by assertions (which have in no way been substantiated and are occasionally untrue) which include a number of "science like" terms and concepts, such as, for example, "condensation of energy," "elastic stress state of ions," "chemical potential of the surface $\frac{\delta F}{\delta S}$," etc., a clear physical meaning for which is not given in the article. This not only does not help to add clarity to the complex phenomenon under study but rather complicates the whole issue.

We should note that applying thermodynamics to the study of movement is, in itself, not completely justified, so long as movement is a process and, consequently, requires a kinetic or dynamic investigation. It seems to me premature to try to find now the rigorous principles of movement in such a complex system of many components, which the soil-water system is. Conducting similar studies on model systems, by which the problem could be resolved under more strict thermodynamic conditions and with fewer variables, would be far more valuable and practicable.

Received April 11, 1959

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A. TYUTYUNOV'S ARTICLE — "INTERACTION OF THE MINERAL ART OF SOIL AND WATER" POCHVOVEDENIYE, 1959, NO.2.

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The article by I. A. Tyutyunov — "Interac- on of the Mineral Part of Soil and Water" has en published in the Journal, Pochvovedeniye, . 2, 1959. The article covers three very portant problems: the thermodynamics of il moisture, the molecular-kinetic (dynamic) echanism of interaction of water and a mine- l skeleton, and the movement of moisture in ils. The author of the article comes forth th his own theory on each of these problems. t us examine these theories in greater detail.

1. Drawing on thermodynamics for studying ocesses occurring in soils and soil materials ars great results. Therefore, we ought to mply welcome Tyutyunov's attempt to advance this direction, if it were not for several rors which he has assumed. Here are a few amples.

In the first two paragraphs on page 30, the lue σ was defined as a specific surface energy a body, while in the paragraph below it was fined as a specific free energy (that is, a rface tension). In addition, the concept of hemical potential of the surface v" (? !) roduced on page 33, is assumed by the thor to be equal to the derivative of the free rface energy F according to the value of the rface S. But since $F = \sigma S$, where σ is the rface tension, independent of S, $v = \frac{dF}{dS} = \sigma$ d, consequently, in Tyutyunov's definition "chemical potential of the surface" turns t to be simply identical to surface tension. us, the most important principles in the rmodynamics of surface phenomena have en confused in this article.

On page 30 the author maintains that "hard ystalline and amorphous bodies which have rfaces of separation are characterized... by condensation of surface energy during inter- tion with other agents (liquid or gas-like)." developing this thesis he writes on page 32: ..in the wetting process of soil, water does not lose heat, but, on the contrary, absorbs it in large quantity and converts it to a higher energy level. At the moment of wetting, the ions, which form the surface of the mineral particle, are converted to an elastic-stress state" (? !)... There are similar statements elsewhere. Thus, running through all the article is the assertion that an increase in internal energy of both the liquid and solid components takes place in the wetting process, which, however, contradicts the second principle of thermodynamics. Actually during wetting the tensions in the surface layer of mineral particles decrease, while the energy level of adsorbed molecules of water is lowered. So long as the initial position of the author is incorrect, the statement stemming therefrom that "the adsorbed water does not freeze... during very low temperatures" owing to the fact that "in the wetting process of soil, the water... is converted to a higher energy level" (page 32), also contradicts the second principle of thermodynamics.

On page 32 the author maintains that "... the surface energy of mineral particles increases with a lowering of temperature." This is not true, because the surface energy actually is an excess potential energy of a unit of surface, caused by a deficiency in neighboring particles in the surface layer. It is obvious that the number of these particles does not depend upon the temperature of the body. Therefore, the surface energy also does not actually depend upon temperature (if we do not consider thermal expansion, which is negligibly small in condensed substances). To prove his position the author refers to experimental data. However, these data in no way confirm his theory, because a change in the quantity of adsorbed matter with temperature under a given absolute vapor pressure was not brought about by a change in the surface energy of mineral particles but, rather, by a change in relative vapor pressure.

2. I. A. Tyutyunov in his article does not

confine himself to the thermodynamic aspect of the problem—he also examines the molecular-kinetic (dynamic) mechanism of interaction of water and mineral soil skeleton (lattice). Unfortunately, we cannot agree here either with most of his ideas.

Examing the process of ion hydration, he writes on page 29: "The complex water aggregates, falling within the sphere of influence of ions, lose hydrogen bonds and are transformed into single molecules..." However, this indicates that "it is impossible to distinguish in water any isolated formations (that is, aggregates—G. M.)... we may speak only of the association of molecules in an arrangement which corresponds to a space lattice (according to X-ray data, which answers ice structure)."[1]

Turning next to the problem of the wetting mechanism, Tyutyunov stresses, throughout, the complete analogy and almost identity of this process with the ion hydration process, which in itself is not true. He writes: "At the moment of wetting, the ions which form the surface... are hydrated, without leaving their places in the crystalline lattice. ... They also destroy the hydrogen bonds of complex water aggregates, orient and condense (compress) the single molecules within the sphere of influence of the field of force of the surface formed by them" (page 30). As a result, free water is converted to a boundary phase[2] consisting of single molecules of water, accordingly oriented and condensed (compressed), which lose the property of gravitational movement. ... The boundary phase may be compared to some extent with the stable bonded water, while the thickness of the film formed by it, evidently, is measured in tens of angstroms" (page 35). Besides, the author introduces the concept of the pre-boundary phase which is situated between the boundary and volumetric phases and "consists of molecules of water, bonded similar to free water, but devoid of a gravitational movement owing to the presence of a hydrogen bond between them and the boundary phase" (page 35). Let us examine these positions of the author in greater detail.

In the first place, the wetting process of soils of varying mineralogical composition takes place in various ways, which Tyutyunov completely ignores. For example, he does not consider that during wetting, crystalline swelling, accompanied by a change in lattice parameters takes place inside, in the montmorillonite, hydromicaceous, and, partly, koalinite clays.

Secondly, the author maintains that in the wetting process, the ions do not forsake their places in the crystalline lattice. As we know, the ions which form the surface are divided into exchangeable and nonexchangeable ions, where the exchangeable ions in the wetting process, by hydrating, leave their place in the lattice, which leads to the formation of a double electrical layer.

Thirdly, the concept that water molecules, which form the hydrate shell of the ion, deprive of hydrogen bonds has not yet been proven. This is especially true for the "boundary phase. On the other hand, if we compute by adsorption isotherms the value of pressure of films, which have a total thickness of 2-3 layers of molecule (that is, <10 Å), we shall see that the pressure will not exceed a hundred atmospheres (as long as the second and subsequent layers, as a rule, are formed under a relative vapor pressure $S \geqslant 0.1 - 0.3$). With an increase in thickness of film to several tens of angstroms (and this is the figure the author takes for the thickness of the boundary phase) the pressure quickly drops to fractions of an atmosphere. As observations have shown, pressure in hundreds and even thousands of atmospheres is not able to change noticeably the structure of water, by disrupting the hydrogen bonds in it. Therefore, the statement that, as a result of excess pressure existing in the "boundary phase", hydroge bond destruction takes place is completely unsubstantiated. We note that this statement is one of the principal ones in Tyutyunov's work.

In the fourth place, the measurements made by B. V. Deryagin and his colleagues showed that liquid viscosity in thin films is greater than in the volumetric phase. However, with thicknesses exceeding 1-2 layers, these change are not so great as to cause the liquid to entire lose its mobility. Therefore, the statement by Tyutyunov that movement of water molecules under action of gravity is impossible, in the boundary and pre-boundary phases, contradicts experimental data.

The statement by the author that "formation of an adsorbed layer of water corresponds in energy to evaporation of the same layer from the free surface (as long as, in one or another case, hydrogen bond destruction occurs)" sounds strange, because, five lines later, in Table 2, he presents the results of experiment by Harkins and Ewing (?), from which we see that in the adsorption, for example, of the firs layer of molecules to titanium dioxide there is given off almost twice as much heat than durin water evaporation.

3. Tyutyunov devotes a large part of his

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[1] SAMOYLOV, O.YA. 1957. Structure of water solutions of electrolytes, and hydration of ions. Published by the Academy of Sciences, USSR, page 68.

[2] By "boundary phase" I. A. Tyutyunov, according to a reference on page 35, intends something quite different than B. V. Deryagin who introduced this term into science.

search to studying the moisture movement ocess in the soil. In this connection he divides e entire process into two stages: "the first ige is the wetting of the surface of mineral rticles and changing of pores; the second ige is the redistribution of water in the oling and subsequent freezing process." is subdivision is hardly expedient, because ovement is possible also in thawed out soil, at is; wihout transition from water to ice.

Examining the movement mechanism, the thor states without any reasons that "distin- ishing the capillary mechanism" or "the rces of menisci" as "driving forces..." (page) is incorrect. But how, then, does moisture ove in sands where quantity of film moisture totally insignificant? How, then, do we plain the rise of water in ordinary capillaries?

On page 33 Tyutyunov writes that "...the atial (? !) movement of film water is realized, en a difference between the chemical poten- als of this water and of the surface of a neigh- ring particle takes place..." The difference chemical potentials of water itself under fferent soil capacities is actually the driving rce (more accurately, the transfer potential) during movement.

4. The errors and inaccuracies assumed by Tyutyunov are not confined to the examples which we have just given. As a matter of fact, the author had not one single original idea in his work with which we could unconditionally agree. Besides, the article has been carelessly written. Here are a few quotes as an example. So, the author writes "...capillaries cannot be a 'mechanism' " (page 34), "water is...a field of force" (page 36), "the elastic-stress state of the surface layer of ions...is their chemical potential" (page 32), etc. The author often uses terms which have no physical meaning (the elastic-stress state of ions, page 32; the condensation of surface energy, page 30, etc.). The same ideas are sometimes repeated in the article several times. For example, the statement that during adsorption, water molecules lose hydrogen bonds without any kind of development or deepening is repeated four times. Besides, the presentation is, in places, illogical (for example, in the first paragraph, on page 34). All this makes the article extremely difficult to read.

Received May 23, 1959

DIFFERENTIAL THERMAL ANALYSIS AS APPLIED TO BUILDING SCIENCE

V.S. RAMACHANDRAN and S.P. GARY (An annotated bibliography)—Central Building Research Institute, Roorke. (India) 1959

This book is an annotated bibliography on thermal analysis problems as applied to the science of building materials. There are six sections in the book; at the end is an index by subject and author.

Section I is devoted to research on experimental procedures.

Section II includes problems of thermal analysis theory.

Section III covers problems on the qualitative and quantitative thermal analysis of clays.

Section IV deals with research on the thermal analysis of building materials (lime, cement, etc.).

Section V deals with research on accessory minerals usually associated with clays.

Section VI covers general problems on differential thermal analysis and its application to different fields.

In addition, the preface contains a description of procedures in thermal analytical research. Mentioned are the most important achievements in differential thermal analysis.

This book is valuable for soil scientists in that we have here a fairly complete bibliograph which covers all the important literature of most countries in the field of thermal analysis of clay and clay minerals, which are widely distributed in soil.

Reviewed by Ye. Shurygina

THE INTERNATIONAL WORKING CONFERENCE ON COMPILATION OF A SOIL MAP OF EASTERN EUROPE

A. A. YEROKHINA

An international conference of compilers of a soil map of Europe was held on June 22-28, 1959 at the V. V. Dokuchayev Soil Institute of the USSR Academy of Sciences. Work on the map is going forward by decision of the fourth International Congress of Soil Science held in Paris in 1956. The International Society of Soil Science Commission No. 5—dealing with the genesis, classification, and mapping of soils—was given the task of organizing the compilation of maps of the continents. Work on the soil map of Europe is co-ordinated by two centers. For FAO member countries, co-ordination is through the Information Center in Ghent (Belgium), under Prof. Tavernier. For eastern European countries which are not members of FAO, co-ordination is through the Dokuchayev Soil Institute in Moscow, under Academician I. V. Tyurin.

The Conference's aim was to co-ordinate operations and agree upon a common legend for the map of Europe to be submitted at the seventh International Congress of Soil Science in the USA in 1960.

A draft legend edited by Academician Tyurin had been compiled by members of the Dokuchayev Soil Institute's Department of the Geography and Cartography of Soils and circulated to those attending. It had served as a basis for soil maps of the countries collaborating on the map. The draft had also been sent to the Information Center with a view to coordinating the map legends for eastern and western Europe.

The following compilers of the map participated in the work of the Conference: Dr. Tanov and Dr. Koynov (Bulgaria), Dr. Stepanovic and Dr. Mate (Hungary), Dr. Kasch and Dr. Kundler (GDR), Prof. Musierowicz (Poland), Prof. Cernescu (Rumania), Dr. Nemecek (Czechoslovakia), Academician Tyurin, Prof. Ivanova, and Candidates of Sciences, Rozov, Fridland, Yerokhina, and Rudneva (USSR). Prof. Tavernier (Belgium) and Dr. Muir (England) took part on behalf of the Information Center. The Soviet Union was also represented by the editors and authors of the World Soil Map and soil map of Asia, Acad. Gerasimov, Dr. Lobova, Prof. Rozanov, and Candidate of Sciences Shuvalov.

The Conference was opened at the Dokuchayev Soil Institute on June 22, 1959, by Acad. Tyurin. His opening statement included a short review of progress on the Soil Map of Europe. He remarked upon the great importance of the soil cartography conferences held in Bucharest and Zagreb in 1958 and of the work done in all the countries engaged in the map's compilation. N. N. Rozov then explained the basic principles of the draft map legend up for discussion. He drew attention to obscure and controversial points which required special consideration.

On June 23 and 24, reports were delivered by representatives of the countries working on the Soil Map of Eastern Europe. They set forth the results of their work and put forward observations and proposals on the draft legend. The reports were accompanied by active discussion.

On June 25, a field trip was made to Zagorsk District in Moscow Region. Its purpose was to acquaint the foreign scientists with sod-podzolic soils. This was of great interest, since the Conference had been discussing the problem of contrasting the soils of central, western and eastern Europe.

On June 26, the Conference heard Prof. Tavernier's report on progress made with the western Europe soil map. He enumerated and described the soil-cartography data available and under preparation. Attention was drawn to the considerable differences between the soil-map legends of different countries: this had emerged particularly strikingly at the conference in the Ghent Information Center in May, 1959. Prof. Tavernier also presented the draft of a collated legend for the southern group of western European countries. This was then discussed.

The session of June 26 had begun with the Conference Chairman, Acad. Tyurin, giving a preliminary summary on some theoretical problems of the genesis and classification of brown forest sod-podzolic and certain other forest soils. Information reports on progress in compiling the new draft of the World Soil Map (Acad. I. P. Gerasimov) and the Soil Map of Asia (Dr. Ye.V. Lobova) were also heard.

On June 26 and 27, sessions were held in two sections. One discussed soil-cartography problems connected with the northeastern group of countries; the other considered problems of the central and southern parts of eastern Europe. The legend and synonyms of soil nomenclature in different countries were examined and contour lines co-ordinated. As a result of this work, agreement was reached on obscure and disputed points in the map legend, and alterations and clarifications were incorporated in the material under review.

This brought the proceedings of the International Working Conference on the Soil Map of Eastern Europe to a close.

A detailed exposition of the questions considered by the Conference and of the discussions held is not possible in this short review (the draft map legend contains over 150 soil symbols, quite apart from soil complexes, texture, and soil-forming parent materials.)

The Conference's main concern were problems connected with the systematics of podzolic, brown forest, and chermozem soils. It was pointed out time and again that the differences between podzolic and sod-podzolic soils are quite substantial, and it is probably as important to bring these out in classification as those distinguishing the sod-podzolic soils from the soils described as "sol lessive" by French authors and "Parabraunerde" by the Germans. In this connection it was suggested that podzolic and sod-podzolic soils be regarded as special types. It was proposed that sod-carbonate soils be distinguished only in the zone of podzolic soils. The suggestion was made that soils developed on strongly carbonate parent materials in the brown earths zone be called "rendzinas."

Considerable attention was paid to the various brown forest (brown-earth) soils. The question was raised of the need to subdivide the heterogeneous group of brown forest soils and to distinguish a number of types in the group. It was proposed in particular that brown forest podzolized (illimerization) soils showing a sharply defined profile differentiation in texture be regarded as an independent type. Geographically they can be regarded as a type similar to the podzolic sod soils of eastern Europe. No final decision was reached on this group of problems.

There was detailed discussion of the problem of subdividing the chernozems, their subdivision into facial groups being the main center of interest. The concensus of opinion was that three separate categories of chernozems needed group designation—eastern European, central European, and southeastern European.

The conference enabled much progress to be made in reconciling points of view on problems concerning the genesis and classification of a number of soil groups. Note was taken of problems requiring further joint research.

The presence of the scientists who are compiling a soil map of the western European countries enabled progress to be made towards agreement on the principles of a legend for the Soil Map of Eastern and Western Europe.

The international working conference recognized the need for further collaboration on a broader basis in compiling soil maps for eastern and western Europe. This extension and development of contacts should be brought about through the exchange of literature and material.

A further conference of compilers of the Soil Map of Eastern Europe attended by representatives of the team compiling the Western Europe map was regarded as desirable, with a view to discussing a final edition prior to the Seventh International Congress of Soil Science, to which the map is to be presented.

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